COSTS AND BENEFITS OF MEETING THE FOOD SUMMIT TARGET

J. Dirck Stryker
Daniel Plunkett
Kathryn Nash
Associates for International Resources and Development

October 29, 2001

APD
Agricultural Policy Development
USAID Contract No.
Prepared for
Office of Economic Growth and Agricultural Development
Global Bureau
U. S. Agency for International Development

TABLE OF CONTENTS

EXECUTIVE SUMMARY iv
Prevalence of Undernutrition v
Causes of Undernutrition vi
Consequences and Opportunities vii
Levels of Interventions vii
Costs of Achieving the Target viii
Benefits from Meeting the Target viii

COSTS AND BENEFITS OF MEETING THE FOOD SUMMIT TARGET 1

COSTS OF MEETING THE FOOD SUMMIT TARGET 4
Prevalence of Undernutrition 4
Causes of Undernutrition 7
Consequences and Opportunities 12
Costs of Achieving the Target 16
Scenario 1: Equal Distribution 16
Scenario 2: Least Cost Distribution 19
Scenario 3: Rational Distribution: Efficiency with equity 20
Scenario 4: Policy Absent 21
Conclusions 21

BENEFITS FROM MEETING THE FOOD SUMMIT TARGET 22
Food Security, Income, and Civil Conflict 22
Conflict Based on Low Income 23
Quantifying these Effects 25
Costs of Civil Conflict 27
Nature of the Costs 27
Cost Estimates 27
Cost of Not Achieving the Food Summit Target 31
Impact of Food Security on Health Care Costs 34
Impact on the Demand for U.S. Agricultural Exports 40
Conclusions 40

REFERENCES 43

ANNEX A 49
Measuring the Level of Undernutrition 50
Assessing the Impacts of Interventions 51
National Level Interventions 55
Intervention 1: Political Stability 56
Intervention 2: Democratization 56
Intervention 3: Economic Openness 57
Intervention 4: Food Tariff Reductions 58
Costs of National Level Policy Interventions 58
Sectoral Level Interventions 59
Intervention 5: Rural Roads 59
Intervention 6: Agricultural Research 60
Household Level Interventions 61
Intervention 7: Targeted Food Aid 61
Intervention 8: Female Secondary School Education 62
Intervention 9: Access to Safe Water 63
The Weighting of Interventions within the Scenarios 63
Limitations 64
Model Organization 74

ANNEX B **75**
Objective 75
Data 75
Regression Results 75
Implications 76

LIST OF TABLES

Table 1: Theoretical Framework for Interventions to Reduce Undernutrition 14
Table 2: Impact of Interventions on Undernutrition -- Scenario 1 17
Table 3: Cost Effectiveness of Interventions under Equal Distribution Scenario 18
Table 4: Impact of Interventions on Undernutrition -- Scenario 2 19
Table 5: Impact of Interventions on Undernutrition -- Scenario 3 20
Table 6: Impact of Interventions on Undernutrition -- Scenario 4 21
Table 7: Peacekeeping and Humanitarian Assistance Costs 29
Table 8: Estimation of Impact of Interventions on Cost of Civil Conflict for Sub-Saharan Africa 33
Table 9: Impact of Rational Distribution Interventions on Number Suffering Undernutrition and Total Calorie Deficit in 2015 38
Table A.1: Assumed Increases in Underlying Variables between 1995 and 2015 51
Table A.2: Parameters Relating Underlying Variables to Child Undernutrition 54
Table A.3: National Level Food Security Strategy 66
Table A.4: Sectoral Food Security Strategy Interventions 67
Table A.5: Household and Intra Household Food Security Strategy Interventions 68
Table A.6: Base Parameters for Food Security Model 69
Table A.7: Analysis of Variables Affecting Percentage of Children Nourished 70
Table A.8: Country Sample and Categorization by Region 71
Table B.1: Infant Mortality and Public Health Care Regressions 76

LIST OF FIGURES

Figure 1: Projecting the Number of People Suffering from Undernutrition in 2015 6
Figure 2: World Undernutrition 1995 and 2015 7
Figure 3: Dietary Energy Supply 10
Figure 4: Income Per Capita 10
Figure 5: Poverty Gap 11
Figure 6: Female Illiteracy Rate 11
Figure 7: Access to Safe Water 12
Figure A.1: Theoretical Construct of the Model 52
Figure A.2: Technical Parameters for the Three Key Variables 53

LIST OF MAPS AND BOXES

Map 1: Level of Child Malnutrition 1990-1995 5
Map 2: Year 2015 Projection of Total Undernutrition 5
Box 1: Note on Assumptions Regarding Ratio of Improvement in Child Malnutrition Relative to That of Adults 55

COSTS AND BENEFITS OF MEETING THE FOOD SUMMIT TARGET

EXECUTIVE SUMMARY

The World Food Summit in 1996 established the target of reducing by the year 2015 the number of undernourished people in the world to one-half the level that existed in the early 1990s. In broad terms this meant reducing the number of undernourished from in excess of 800 million to a target of 400 million. Although recent trends suggest that the percentage of undernourished is currently falling in most areas of the world, the same cannot be said of the absolute number of undernourished unless there is an increased effort to achieve this target. Furthermore, even the percentage of undernourished is projected to rise in some countries, especially in sub-Saharan Africa. With the world population expected to continue rising, this implies that there must be a reduction in the number of undernourished by more than 500 million people if the target is going to be met.

Within the United States, an Inter-Agency Working Group (IWG) was created after the Food Summit to prepare an Action Plan in support of the achievement of the World Food Summit target not only at the global level but also on the domestic front. As an input into this plan, Associates for International Resources and Development (AIRD) was asked, under the APAP III project led by Abt Associates, to prepare a report which would analyze the prevalence and causes of world undernutrition, assess alternative approaches for achieving the Food Summit target including their cost effectiveness in meeting this goal, analyze the comparative advantage of the U.S. over other donors in working towards the target, and specify a strategy for the U.S. to pursue (Stryker and Metzel, 1998). The results of this exercise were subsequently incorporated into the U.S. Action Plan on Food Security (1999).

The World Food Summit will be revisited in November 2001, on its fifth anniversary. This will be the occasion to review the progress that has been achieved and what remains to be done. As an input into these deliberations, AIRD was contracted by the U.S. Agency for International Development under the APD project, again led by Abt, to update the earlier model and, in addition, to estimate some of the benefits that would result from achievement of this target.

The report uses the AIRD Food Security Model to analyze the costs of meeting the Food Summit target. Based on detailed data for 99 developing countries, the model assesses the levels of undernutrition by major country and sub-region at the time of the Food Summit. It also projects to the year 2015 the number of people in the world who will still be in a state of undernutrition assuming no change in the actions taken that could reduce that number.

Estimating the costs and benefits of eliminating hunger for more than 500 million people is an awesome task by any standard. The reasons for the prevalence of hunger and undernutrition in the world are multiple and complex. Even agreeing on what standard to use is not as evident as it might seem. Furthermore, this analysis is restricted to a limited number of fairly clearly specified variables – either the kinds of interventions that might be made to reduce hunger or some of the measurable benefits that can be achieved. The most important benefits – the reduction in pain and suffering of those affected – are not included in the analysis, not because

they are not important -- they most certainly are -- but because they are so difficult to record in terms of dollars and cents. The report concentrates on the costs and benefits of reducing hunger primarily from the perspective of the donors. This is done because the report is meant to influence donor decisions regarding where to allocate resources. It therefore leaves out estimation of the costs and benefits to local governments, private firms, farmers, and consumers. In one sense, however, this is not so severe an omission. Achieving the food summit target will require the marshalling of extraordinary resources. Most of the poor countries in which the majority of undernourished live simply do not have the resources that are necessary to undertake this task. Thus, the supplemental contribution that is necessary to reach the target will have to come in large part from the donors.

The calculations described in the report are based on the latest available data and empirical estimations. However, much of this is pretty approximate. Parameters are used and assumptions are made that may not be fully justified. Many conceptual issues exist that have not been fully explored and on which there is not yet full agreement. Furthermore, no effort has been made to discount future benefits and costs. For example, it is assumed that that most interventions to decrease undernutrition and the benefits resulting from this decrease will take place over most of the time remaining until the year 2015. Yet the costs will often be incurred up front. A more precise analysis would discount these costs and benefits. This is not done because this would presuppose a degree of precision regarding their timing that does not exist.

Nevertheless, the basic finding of the report – that the costs of achieving the target are reasonably low and the potential benefits are quite high – is very robust. Changes in a few parameters or assumptions, or discounting costs and benefits over time, would not alter this fundamental conclusion.

Prevalence of Undernutrition

In 1995, the number of people suffering from undernutrition in the world totaled about 854 million. This figure is expected to increase to about 911 million by the year 2015 unless further action is taken. Particularly striking is the distribution of the prevalence of undernutrition across regions and countries. There are high rates of undernutrition in sub-Saharan Africa (SSA), South Asia, and some parts of Southeast Asia. Rates are relatively low, for the most part, in North Africa, South America, and the Middle East. They are somewhat higher in Central America and parts of the Caribbean.

Projected rates of child undernutrition by country incorporate the estimates of the International Food Policy Research Institute (IFPRI), which calculates child malnutrition based on IFPRI's Vision 2020 projections of food availability, modified to allow for the effects of estimated changes by the year 2015 in women's rates of secondary school enrollment and in the percentage of the population with access to safe water. In addition, AIRD has extended these projections to include countries not based in the IFPRI sample, but for which there are data on the prevalence of undernutrition from FAO. Rates of child undernutrition were extrapolated to the entire population using the methodology described in Annex A.

Most of the world's undernutrition is concentrated in Asia. With the exception of a few

countries in Southeast Asia, such as Indonesia, Philippines, and Vietnam, where the incidence of undernutrition is still quite high, undernutrition in that region is either low or is decreasing fairly rapidly. In South Asia, on the other hand, more than 50 percent of the children under five years of age suffer undernutrition, as measured by weight for age, in Bangladesh, India, and Nepal. The percentages in Pakistan and Sri Lanka are also high.

Sub-Saharan Africa is the other region where there is substantial undernutrition. Many of the countries in which undernutrition is highest have experienced major war and civil strife in recent years. The trend in most of these countries is for a continued increase in the absolute number of those suffering undernutrition, and also, in many cases, in the relative prevalence of undernutrition.

Causes of Undernutrition

The causes of undernutrition are multiple and complex. They include limited availability of food within a country or region, weak access of household and individuals to food, and poor utilization of food by individuals. Among the critical variables are:

- food availability;
- per capita real GDP at the national level;
- prevalence and depth of poverty;
- illiteracy among women;
- access to safe water and sanitary facilities.

We can define the broader dimensions of the principal causes of undernutrition in different regions. In South Asia, which has the highest levels of undernutrition in the world, the problem is not so much inadequacy of food supply, except possibly in Bangladesh. Nor is it one of very low levels of per capita real GDP. Rather it appears to be due to several interacting factors:

- lack of access by poor households and other vulnerable groups to adequate quantities of safe, good quality nutritious foods;
- low education and social status of women, which results in their having little command over the distribution of food to women and children within the household;
- high population density, a humid monsoon climate, and poor access to safe water and sanitation, which leads to poor health and inhibits the utilization of ingested nutrients.

In sub-Saharan Africa, on the other hand, the problem is much more one of low levels of food availability and low per-capita real GDP, especially in the war-torn and least developed countries.

Without additional intervention, some regions are expected to improve on their own as the contribution of food availability and education, resulting in better utilization of resources, grows at a rate faster than population growth. But other regions are expected to continue to worsen in both absolute and relative terms. The main emphasis will therefore be needed in the lagging regions, e.g. sub-Saharan Africa and parts of South Asia.

Consequences and Opportunities

The consequences of the high levels of undernutrition that exist in the world are severe. Above all, they are severe for the more than 800 million people that presently suffer from chronic hunger. Aside from their physical distress, these people are less able to work, reducing the income they can earn for themselves and for the nation. They are more vulnerable to diseases such as HIV/AIDS or malaria. Poverty and undernutrition thus play upon one another in a vicious cycle that has a number of adverse results.

First, this vicious cycle can lead to political and military crisis. Second, chronic undernutrition creates conditions of uncertainty regarding emergency food aid. Third, poverty and undernutrition feed upon one another in ways that limit the development of local markets for food. This decreases the reliability of markets in these countries for exports from the food-surplus countries, including the United States. Finally, the vicious cycle of poverty and undernutrition sets back the spread of democracy and good governance to the developing nations. This encourages corruption, lack of transparency, and poor governance.

The establishment of the Food Summit target presents a unique opportunity to act effectively to break this vicious cycle. The target is visible, measurable, and attainable. It can be achieved, as this report demonstrates, without enormous financial sacrifice.
The moment is appropriate because of a confluence of factors. First, the U.S. agricultural community has developed a strong global perspective regarding its own self-interests. Second, the policy environment in many developing countries has improved enormously since the mid-1980s. This means that interventions to increase food security through productive investments that may have failed 15 years ago are much more likely to succeed today. Finally, the world is currently experiencing, at the global level, a period of relative peace and prosperity that has not existed for almost a century.

Levels of Interventions

There are a number of different levels at which interventions can be undertaken to alleviate hunger and undernutrition. These levels may be global, national, sectoral, or household. At the global level, it is important that sufficient food be produced to feed the world's population adequately. It is also important that global markets and other institutions operate effectively to permit food to move reliably from areas of surplus to areas of deficit. Global actions must also help ensure that there is peace and a high degree of physical security in these countries and regions afflicted by undernutrition if food supplies are to be transported safely within the country and if stocks of food are to be secure. This requires conflict prevention and resolution whenever possible.

Interventions at the national level include the promotion of democracy in rural areas and the creation of an enabling environment for trade and investment. Effective political advocacy helps to ensure that the rural population receives its fair share of infrastructure, such as roads, irrigation works, schools, health facilities, and safe water and sanitation. A policy environment opened to international trade and investment is important for higher rates of economic growth, which in turn raises national and rural incomes. The result is increased availability of and access

to food, more education for women, and better access to safe water and sanitation, all of which reduce undernutrition. In addition, countries can benefit by reducing trade taxes and other barriers to food imports, actions that lower food prices and increase real incomes used to purchase food.

At the sectoral level, the two most important types of interventions are investment in productive rural infrastructure and in agricultural research, extension, and education. These increase agricultural productivity, which in turn raises national income through a multiplier effect. The result is both a direct contribution to food availability through increased food production and an indirect increase in food availability, women's education, and safe water and sanitation because of higher national income.

At the household level, the most effective way of improving nutrition is to direct interventions towards women. One approach, which has been used quite successfully in a number of countries under Title II food aid, is to channel resources through local projects such as maternal and child health programs and small-scale agricultural projects. In addition, some of the aid can be channeled to participants directly in the form of food assistance. Finally, investment in women's education, especially at the secondary school level, has been shown to have important nutritional benefits.

Costs of Achieving the Target

In order to estimate the cost of achieving the Food Summit target of reducing the number of undernourished to 400 million by the year 2015, empirically derived parameters were used to link the interventions discussed above to resulting declines in undernutrition. The cost of each intervention, presented in detail in Annex A, was then multiplied by the scale of the intervention, with some allowance for decreasing returns, in order to derive total costs for that intervention. Four scenarios were then developed using different combinations of these interventions to achieve the Food Summit target.

The report estimates the costs associated with alternative approaches to reducing hunger and assesses the effort needed to meet the Food Summit target under four different packages of interventions. It concludes that the total cost of reaching the target could be in the range of **$72-$126 billion, with the most rational strategy costing about $80 billion**. Stretched out over 13 years, this amounts to about a 11 percent increase in the annual level of Official Development Assistance by all the donors belonging to the Organization for Economic Cooperation and Development (OECD).

Benefits from Meeting the Target

The benefits of meeting the Food Summit target are very substantial. Those that are measured here include decreased costs of humanitarian assistance and peacekeeping operations associated with civil conflict, lower requirements for public health expenditures, and decreased costs of treating HIV/AIDS. Each of these cost savings is estimated using empirical parameters that have been derived from at least one study in each area, based in each case on cross-country data. The broad cross-country results are complemented by substantial qualitative and quantitative

evidence at the micro level concerning the relationships specified. Most important, the cross-country results all point to very large benefits resulting from improved food security to meet the Food Summit target – benefits that more than offset the costs involved.

The analysis is focused particularly on sub-Saharan Africa because it is here where the problems of civil conflict and HIV/AIDS arising out of poverty and food insecurity are most prevalent in terms of the numbers of food insecure who are likely to be affected. In South Asia, by contrast, the very large number of people who are undernourished live in areas in which there is little civil conflict. HIV/AIDS is also less of a problem, though it could become one. Another reason for focusing on Africa is that it is here where the problem of food insecurity can best be solved by donor contributions to increasing agricultural production. In South Asia, on the other hand, the problems are related more to improving the distribution of income and enhancing the status of women, two areas in which the donors are likely to have less of an influence no matter what level of assistance they offer.

There is widespread evidence that civil conflict is closely associated with poverty and food insecurity. Using empirically estimated parameters for this association, cost savings in Africa would be $2.5 billion per year for all donors and $0.9 billion for the United States. This compares with estimated current expenditures for peacekeeping and humanitarian assistance in Africa of $3.3 billion for all donors and $1.2 billion for the United States (assuming that 40% of total expenditures go for Africa, as discussed above). Thus, improving food security in line with meeting the Food Summit target would reduce peacekeeping and humanitarian assistance costs in Africa by about 80%. Furthermore, although these benefits would accrue gradually over a period of ten years, they would continue to persist after the costs of improving roads and undertaking research have already been incurred.

The impact of improved nutrition on public health expenditures is shown to be even more important. Meeting the Food Summit target, according to the estimates reported earlier, would save $8.9 per annum for each person in the developing countries – or a total of $52 billion (PPP 1985 dollars) per annum, compared with the total value of public health expenditures for these countries of about $190 billion (PPP 1985 dollars). Given current pressures for donors to contribute substantially to improvements in public health in these countries, the saving to the donors are likely to be very considerable.

In addition to these overall savings, there would also likely be a very considerable impact on the prevalence of HIV/AIDS, especially in Africa. According to the empirical evidence that is available, for every 100 kcal of additional food consumption, the prevalence of HIV would decrease by about 5 percentage points. Given the increase in agricultural production in Africa necessary to meet the Food Summit target, the decline in the prevalence of HIV could be about 1.5 percentage points on average. Elsewhere it would be much less, but overall there might be potential savings in excess of $18 billion annually to the extent that the need for treatment of HIV/AIDS was otherwise to be met. There would, of course, be many other benefits to those suffering from AIDS and their families, which have not been included in this analysis.

It is important to recognize that the medical profession is not yet fully agreed that the evidence supporting the link between nutritional status and rates of infection of HIV is solid enough that it

can form the basis for major policy decisions. Thus, one should not reach the conclusion that other approaches to the prevention of HIV/AIDS through education, distribution of condoms, and other means should be reduced so as to concentrate more on improving food security. Reduction in the frequency of exposure to the virus may still be the most effective approach. However, it may not be the only approach, and it is important that the benefits of reduced infection associated with improved nutritional status not be ignored. In the longer run, this could prove to be a very important tool in the fight against HIV/AIDS, and one that is quite cost effective.

Finally, the increase in agricultural production required to meet the Food Summit target would generate annually about $116 billion in additional demand for all imports and $33 billion in additional demand for agricultural imports. Although not all of these imports would come from the U.S., the impact on the world market would be appreciable.

Not all the benefits from meeting the Food Summit target have of course been estimated. Aside from the relief of pain and suffering for the hungry and the sick, there are also likely to be substantial gains in terms of increased worker productivity and improved educational attainment. These have not been estimated here because most of the evidence is at the micro level and is not based on broad samples, but it is nonetheless very substantial. Should these gains be added, the benefits would total many billions of dollars. Even in their absence, the quantitative benefits appear to far outweigh the costs

COSTS AND BENEFITS OF MEETING THE FOOD SUMMIT TARGET

The World Food Summit in 1996 established the target of reducing by the year 2015 the number of undernourished people in the world to one-half the level that existed in the early 1990s.[1] In broad terms this meant reducing the number of undernourished from in excess of 800 million to a target of 400 million. Although recent trends suggest that the percentage of undernourished is currently falling in most areas of the world, the same cannot be said of the absolute level of undernourished unless there is an increased effort to achieve this target. Furthermore, even the percentage of undernourished is projected to rise in some countries, especially in sub-Saharan Africa. With the world population projected to continue rising, this implies that there must be a reduction in the number of undernourished by more than 500 million people if the target is going to be met.

Within the United States, an Inter-Agency Working Group (IWG) was created after the Food Summit to prepare an Action Plan in support of achieving the World Food Summit target not only at the global level but also on the domestic front. As an input into this plan, Associates for International Resources and Development (AIRD) was asked, under the APAP III project led by Abt Associates, to prepare a report which would analyze the prevalence and causes of world undernutrition, assess alternative approaches for achieving the Food Summit target including their cost effectiveness in meeting this goal, analyze the comparative advantage of the U.S. over other donors in working towards the target, and specify a strategy for the U.S. to pursue (Stryker and Metzel, 1998). The results of this exercise were subsequently incorporated into the U.S. Action Plan on Food Security (1999).[2]

The World Food Summit will be revisited in November 2001, on its fifth anniversary. The purpose of the summit will be to review the progress that has been achieved and assess what remains to be done. As an input into these deliberations, AIRD was contracted by the U.S. Agency for International Development under the APD project, again led by Abt, to update the earlier model and, in addition, to estimate some of the benefits that would result from achievement of this target.

Estimating the costs and benefits of eliminating hunger for more than 500 million people is an awesome task by any standard. The reasons for the prevalence of hunger and undernutrition in the world are multiple and complex. Even agreeing on what standard to use is not as evident as it might seem. Furthermore, this analysis is restricted to a limited number of fairly clearly

[1] The World Food Summit made reference to reducing the number of "undernourished", defined in terms of calorie deficiency. This report concentrates on the problem of "undernutrition", resulting from lack of adequate absorption of calories by the human body. As explained further, although not an exact substitute for the World Food Summit term, undernutrition is a close proxy and in some ways goes beyond the problem of deficiency arising from limited availability of and access to adequate calories to include their utilization as well. Both terms contrast with "malnutrition", which may be due to deficiencies of protein or micro-nutrients, as well as to calorie deficiency. Although the problem of micro-nutrient deficiency is severe in some parts of the world -- especially with respect to vitamin A, iron, and iodine – the solutions to this problem are quite different from those for overcoming calorie deficiency.

[2] The AIRD Food Security Model, used for this analysis, was developed by the late Jeffrey Metzel, who was tragically killed in an airplane accident in West Africa on January 30, 2000.

specified variables – either the kinds of interventions that might be made to reduce hunger or some of the measurable benefits that can be achieved. The most important benefits – the reduction in pain and suffering of those affected – are not included in the analysis, not because they are not important -- they most certainly are -- but because they are so difficult to record in terms of dollars and cents. The report concentrates on the costs and benefits of reducing hunger primarily from the perspective of the donors. This is done because the report is meant to influence donor decisions regarding where to allocate resources. It therefore leaves out estimation of the costs and benefits to local governments, private firms, farmers, and consumers. In one sense, however, this is not so severe an omission. Achieving the food summit target will require the marshalling of extraordinary resources. Most of the poor countries in which the majority of undernourished live simply do not have the resources that are necessary to undertake this task. Thus, the supplemental contribution that is necessary to reach the target will have to come in large part from the donors.[3]

The calculations described in the report are based on the latest available data and empirical estimations. However, much of this is pretty approximate. Parameters are used and assumptions are made that may not be fully justified. Many conceptual issues exist that have not been fully explored and on which there is not yet full agreement. Furthermore, no effort has been made to discount future benefits and costs. For example, it is assumed that that most interventions to decrease undernutrition and the benefits resulting from this decrease will take place over most of the time remaining until the year 2015. Yet the costs will often be incurred up front. A more precise analysis would discount these costs and benefits. This is not done because this would presuppose a degree of precision regarding their timing that does not exist.

Nevertheless, the basic finding of the report – that the costs of achieving the target are reasonably low and the potential benefits are quite high – is very robust. Changes in a few parameters or assumptions, or discounting costs and benefits over time, would not alter this fundamental conclusion.

The next section of the report uses the AIRD Food Security Model to analyze the costs of meeting the Food Summit target. Based on detailed data for 99 developing countries, the model assesses the levels of undernutrition by major country and sub-region at the time of the Food Summit. It also projects to the year 2015 the number of people in the world who will still be in a state of undernutrition assuming no change in the actions taken that could reduce that number.

The report estimates the costs associated with alternative approaches to reducing hunger and assesses the effort needed to meet the Food Summit target under four different packages of interventions. It concludes that the total cost of reaching the target could be in the range of **$72-$126 billion, with the most rational strategy costing about $80 billion**. Stretched out over 13 years, this amounts to about an 11 percent increase in the annual level of Official Development

[3] FAO has estimated that aggregate annual investment needed to cut world hunger in half is $180 billion per year, of which the current level reaches only $150 billion. Combined with our estimates of the donors' contribution, this would imply that new investment by local governments, private sector interests, and African populations would have to be four times higher than that of the donors (FAO 2001a). As discussed below, however, we believe that FAO has overestimated the investment necessary to achieve the target. In any event, it seems clear that most of the additional resources will have to come from the donors.

Assistance by all donors belonging to the Organization for Economic Cooperation and Development (OECD). The costs associated with each of the four different intervention packages are given below:

Costs of Meeting the Target

How Much Will It Cost the OECD Donors?

Least-Cost Scenario (Educate women in South Asia and China)	$72 billion
Rational Scenario **("Efficiency with Equity" = emphasis on Africa)**	**$80 billion**
Equal Distribution Scenario (Funds spent equally across regions and interventions)	$125 billion
Policy Absent Scenario (Only sectoral and household interventions)	$126 billion

It should be noted that these costs have increased since the first report was prepared two years ago. This is because of the increasing difficulty in achieving the target as we approach the year 2015. For example, in 1998, the cost of the "Rational Scenario" was $71 billion; today it is $80 billion.

The second major section of the report assesses some of the benefits that would be achieved if the target were to be reached. These include a reduction in the cost to the donors of humanitarian assistance and peacekeeping operations associated with civil conflict, a decline in the cost of public health, a decrease in the cost of treating HIV/AIDS, and increased income resulting from an increase in agricultural productivity.

Some of these benefits accrue primarily to the donors. For example, the reduction in the cost to the donors of humanitarian assistance, peacekeeping operations, and aid to refugees associated with civil conflict is estimated at $2.5 billion per annum. Other savings accrue to both donors and host country governments. Based on the empirical analysis contained in this report, we estimate that meeting the Food Summit target will generate savings in public health expenditures in the developing countries worth $52 billion (PPP 1985 dollars) per annum. This may be compared with total public health expenditures in these countries of about $190 billion (PPP 1985 dollars) per annum. There also appears to be a good chance that the fight against hunger could contribute to a reduction in infection from HIV. The savings here are speculative, but could be on the order of more than $18 billion annually if donors and host country governments chose to fund fully the treatment of HIV/AIDS in developing countries. Finally, the benefits to the donors include an increase in demand for imports by the developing countries, including agricultural imports, due to their gains in agricultural production and, through the multiplier

effect, in GDP. These increases are estimated to equal $116 billion in total imports and $33 billion in agricultural imports.

COSTS OF MEETING THE FOOD SUMMIT TARGET

This section estimates the cost of meeting the World Food Summit target. It first examines the prevalence of undernutrition, both in 1995, at the time of the World Food Summit, and as projected to 2015. Following this, there is a brief examination of the causes of undernutrition, with special attention paid to the paradox of South Asia. Subsequently, the consequences of undernutrition are discussed, along with the opportunities that exist for dealing with it in terms of alternative types of intervention. The last section looks at the costs of these interventions in terms of a series of scenarios, representing alternative intervention packages.

Prevalence of Undernutrition

In 1995, the number of people suffering from undernutrition in the world totaled about 854 million.[4] This figure is expected to increase to about 911 million by the year 2015 unless further action is taken. This does not imply that no progress is being made in reducing world hunger. In many areas of the world, the percentage of those suffering from undernutrition is decreasing. This is not true everywhere, however, and even where it is true, growth of population often increases their absolute number.

Particularly striking is the distribution of the prevalence of undernutrition across regions and countries at the time of the World Food Summit, as shown in Map 1. These figures relate to data on child malnutrition, or low weight for age, thus providing an indication of physical status, unlike estimates derived from data on food availability.[5] They show high rates of undernutrition in sub-Saharan Africa (SSA), South Asia, and some parts of Southeast Asia. Rates are relatively low, for the most part, in North Africa, South America, and the Middle East. They are somewhat higher in Central America and parts of the Caribbean.

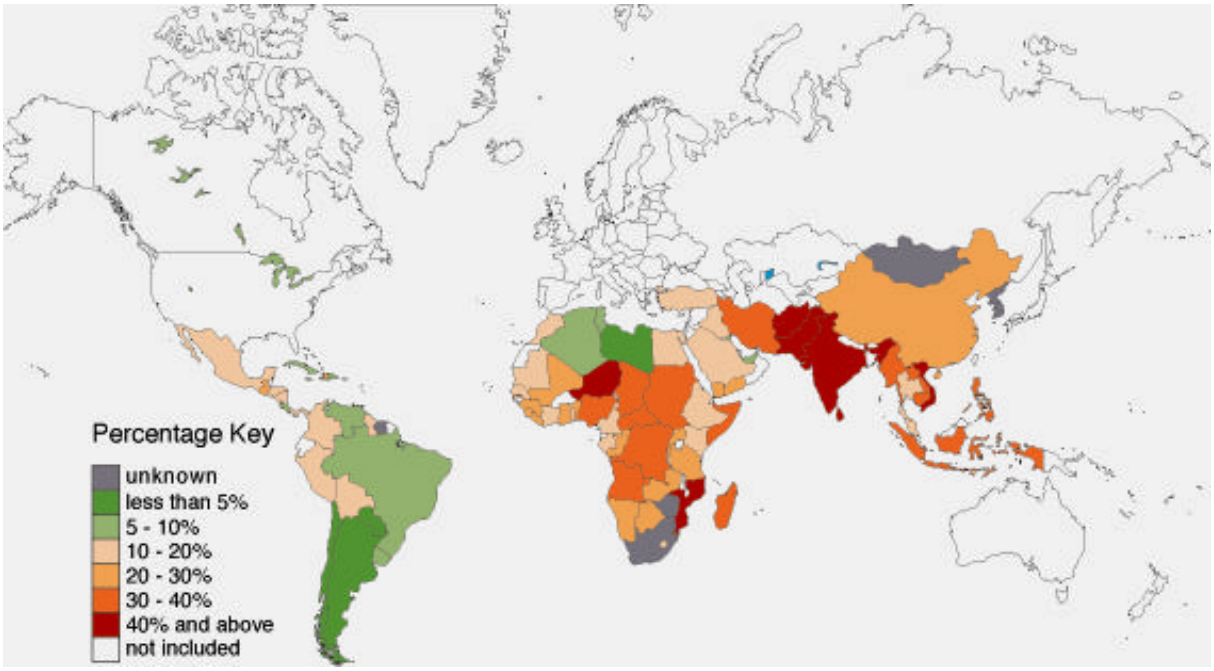
Map 2 shows projected rates of child malnutrition by country in the year 2015. These projections incorporate the estimates of the International Food Policy Research Institute (IFPRI), which project child malnutrition based on IFPRI's Vision 2020 projections of food availability, modified to allow for estimated changes by the year 2015 in women's rates of secondary school

[4] This figure differs somewhat from the number estimated by FAO for 1990-92 of 841 million undernourished. The FAO estimate is based on food availability calculated from food balance sheets with an adjustment for the distribution of food intake within countries. A minimum requirement is established for each country, and the percentage of the population falling below this requirement is considered chronically undernourished (FAO, 1996). In contrast, the number reported here is based on the percentage of children underweight (as measured by weight for age) in 1988-92 from Smith (1998), adjusted for population change to 1995 and extrapolated to cover the entire population (see Annex A for the methodology). Although the two numbers do not differ very much in total, the differences are much larger across regions. In particular, undernutrition is much greater in South Asia than would be predicted by the data on food availability. The FAO is well aware of this, having published child malnutrition data obtained from anthropometric surveys in addition to the estimates of chronic undernutrition from data on food availability (FAO, 1996).

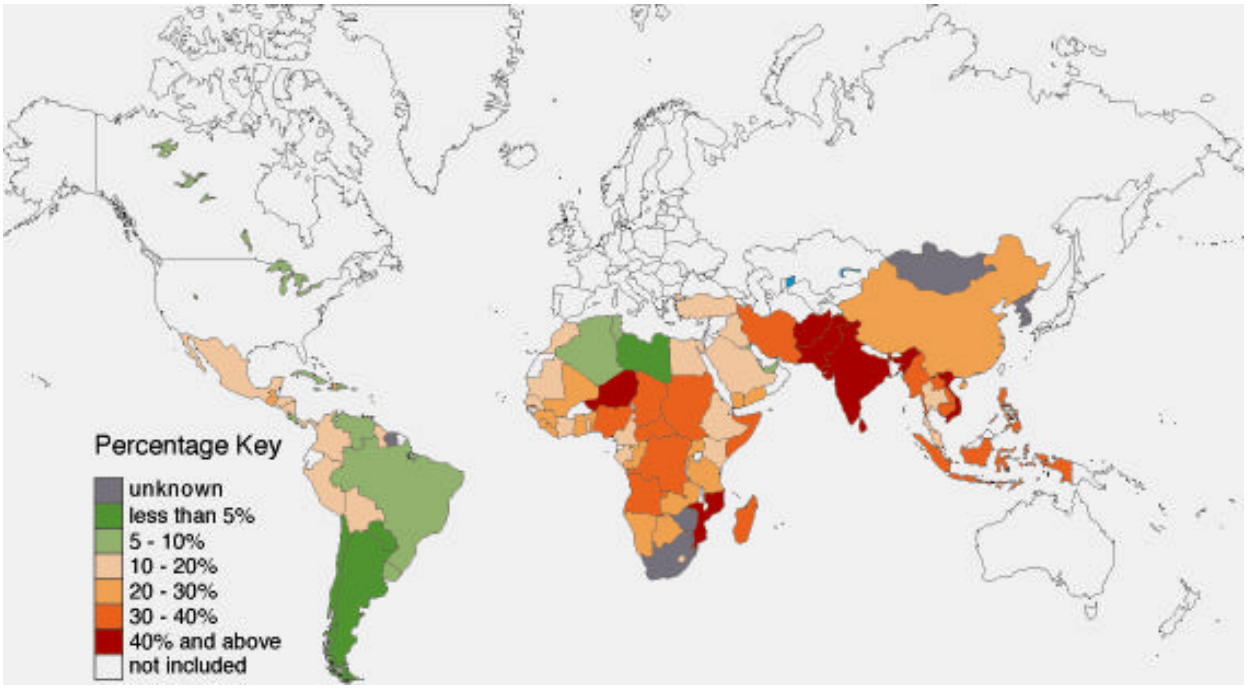
[5] Anthropometric measures of child malnutrition are a relatively reliable proxy for child undernutrition. For the purposes of this analysis, child malnutrition and child undernutrition are considered largely synonymous.

enrollment and in the percentage of the population with access to safe water. In addition, AIRD has extended these projections to include countries not based in the IFPRI sample but for which there are data on the prevalence of undernutrition from FAO.

Map 1: Level of Child Malnutrition 1990 - 1995



Map 2: Year 2015 Projection of Total Undernutrition



Maps 1 and 2 indicate relative rates of undernutrition for the population of children under 5 years of age, but they do not show where the absolute level of undernutrition is greatest. For this to be meaningful in terms of the Food Summit target, undernutrition has to be measured for the entire population. Accordingly, the 1995 rates of child malnutrition and the projected rates for 2015 were extrapolated to the entire population using the methodology described in Annex A, and the results were then expressed in absolute terms. Figure 1 illustrates how the total number of 911 million people in a state of undernutrition in 2015 is derived.

Figure 1: Projecting the Number of People Suffering from Undernutrition in 2015

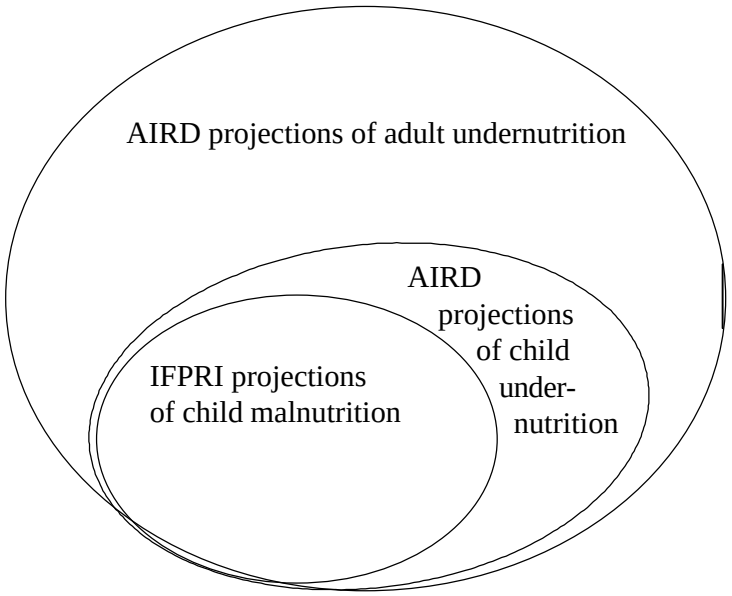
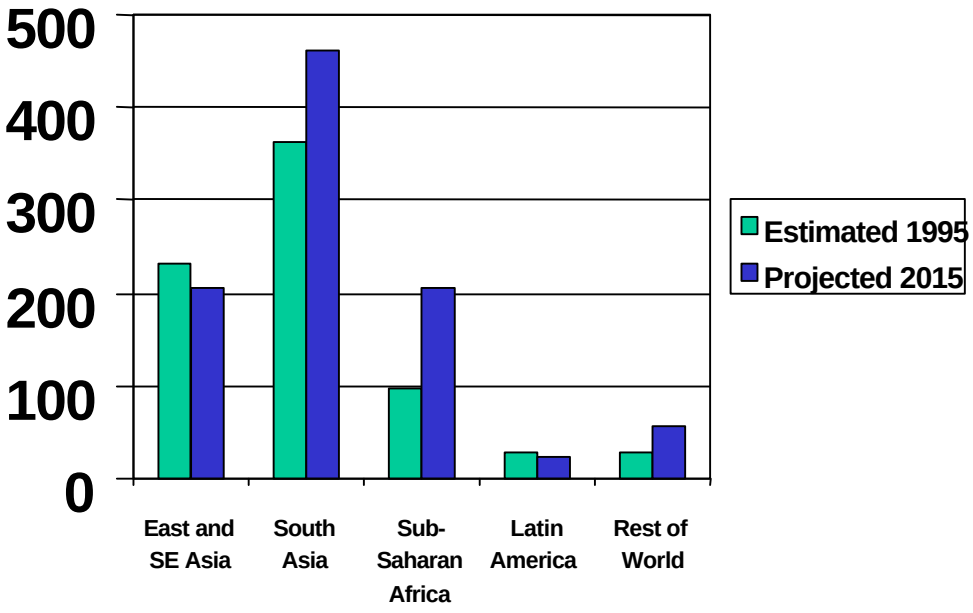


Figure 2 shows that most of the world's undernutrition is concentrated in Asia. The results are very different, however, for South Asia as compared with East and Southeast Asia. With the exception of a few countries in Southeast Asia, such as Indonesia, Philippines, and Vietnam, where the incidence of undernutrition is still quite high, undernutrition in the region is either low or is decreasing fairly rapidly. Even these three countries are witnessing a steady decline in undernutrition. In South Asia, on the other hand, more than 50 percent of the children under five years of age suffer undernutrition, as measured by weight for age, in Bangladesh, India, and Nepal. The percentages in Pakistan and Sri Lanka are also high. Although the prevalence of undernutrition is decreasing in many of these countries, the absolute numbers of those suffering undernutrition are rising.

Sub-Saharan Africa is the other region where there is substantial undernutrition. Many of the countries in which undernutrition is highest have experienced major war and civil strife in recent years. Examples include Angola, Congo, Ethiopia, Mozambique, Rwanda, Somalia, and Sudan. Other countries, such as Central African Republic, Chad, Mali, and Madagascar, have been persistently poor and underdeveloped. The trend in most of these countries is for a continued increase in the absolute number of those suffering undernutrition, and also, in many cases in the relative prevalence of undernutrition. On average, for example, undernutrition in Africa is projected to increase by 50 percent over the next 20 years.

Figure 2

World Undernutrition
1995 and 2015 (Millions)



Causes of Undernutrition

The causes of undernutrition are multiple and complex. They include limited availability of food within a country or region, weak access of household and individuals to food, and poor utilization of food by individuals. [6] Among the critical variables are:

- food availability, which equals production plus imports minus exports, with adjustment for changes in stocks and for feed, seed, and losses;
- per capita real GDP at the national level, which is related to the ability of households on average to grow or purchase food, but is also related to the ability of governments to provide facilities for education and health, which also have an influence on nutrition;
- prevalence and depth of poverty, which shows the extent and degree to which some households are below the poverty line regardless of the overall national level of per capita income;
- illiteracy among women as a measure of the education and status of women, which are important variables influencing intra-household allocation of food and the control

[6] Rodgers (1990); Haddad et al. (1997). This point is also made in several FAO technical working papers prepared for the World Food Summit.

and management of household resources and the provision of health care;[7]

- access to safe water and sanitary facilities, which is an important measure of the health of the population, especially in humid areas with high population density, where endemic parasitic and other diseases inhibit the ability to absorb nutrients from food that is ingested.[8]

Figures 3 through 7 show the levels of each of these variables by region. East and Southeast Asia includes China, Indonesia, and Rest of East and Southeast Asia. South Asia includes Bangladesh, India, Pakistan, and Rest of South Asia. Sub-Saharan Africa includes Ethiopia, Nigeria, War-Torn sub-Saharan Africa, Developing sub-Saharan Africa, and Least-Developed sub-Saharan Africa. Other regional categories include Latin America and the Caribbean and the Rest of the Developing World.

Figure 3 shows the level of per capita food availability, expressed as Dietary Energy Supply (DES) in kilocalories per day, at the time of the World Food Summit (FAO 1996). The region of East and Southeast Asia clearly has the highest level of food availability, followed closely by Latin America and the Caribbean. South Asia is substantially behind these regions but is well ahead of sub-Saharan Africa. A similar picture emerges from Figure 4 with respect to per-capita real GDP, measured in 1985 purchasing power parity prices. Within Africa, however, at the time of the World Food Summit, the developing nations had an average per capita GDP of $1,646, while the war-torn and least developed nations had a per-capita GDP of $644 and $666 respectively.

Average per capita real GDP is only one indicator of poverty since it does not take into account the distribution of income within a country. A better measure is the depth of poverty, defined as the cumulative gap by which income of poor households falls below the poverty line. This variable, taken from the World Bank (1998), is shown in Figure 5. It suggests a substantial degree of poverty within South Asia and sub-Saharan Africa, especially the least developed countries of SSA.

The low status of women in South Asia is demonstrated in Figure 6, which shows the very high female illiteracy rates that prevailed there at the time of the World Food Summit. Illiteracy is also high for women in SSA, though the difference between the rates for women and men is not as great as in South Asia. Finally, Figure 7 suggests the importance of health problems in all regions arising because of low rates of access of the population to safe water and sanitation.

In summary, we can define the broader dimensions of the principal causes of undernutrition in

[7] King and Hill (1993) review the state and implications of women's education and the extent of the gender gap in education for 152 countries covering the period 1960 through 1985. They also seek to understand why gender gaps exist. Pitt (1995) evaluates the direct and indirect effect of mother's education on child health for 14 sub-Saharan African countries. Glewwe (1997) has empirical evidence from Morocco that women primarily use the literacy and numeracy skills acquired in school to assist them in diagnosing and treating child health problems or interacting with health care providers. This also suggests that direct teaching of health knowledge skills in school could substantially raise child health and nutrition.

[8] Empirical evidence from Rwanda illustrates the importance of health infrastructure and sanitary environment in the nutritional status of household members (Schnepf 1991).

different regions. The absolute number suffering undernutrition varies greatly by region, as do the causes. In South Asia, which has the highest levels of undernutrition in the world, the problem is not so much inadequacy of food supply, except possibly in Bangladesh. Nor is it one of very low levels of per capita real GDP. Rather it appears to be due to several interacting factors:

- lack of access by poor households and other vulnerable groups to adequate quantities of safe, good quality nutritious foods;
- low education and social status of women, which results in their having little command over the distribution of food to women and children within the household;
- high population density, a humid monsoon climate, and poor access to safe water and sanitation, which leads to poor health and inhibits the utilization of ingested nutrients.

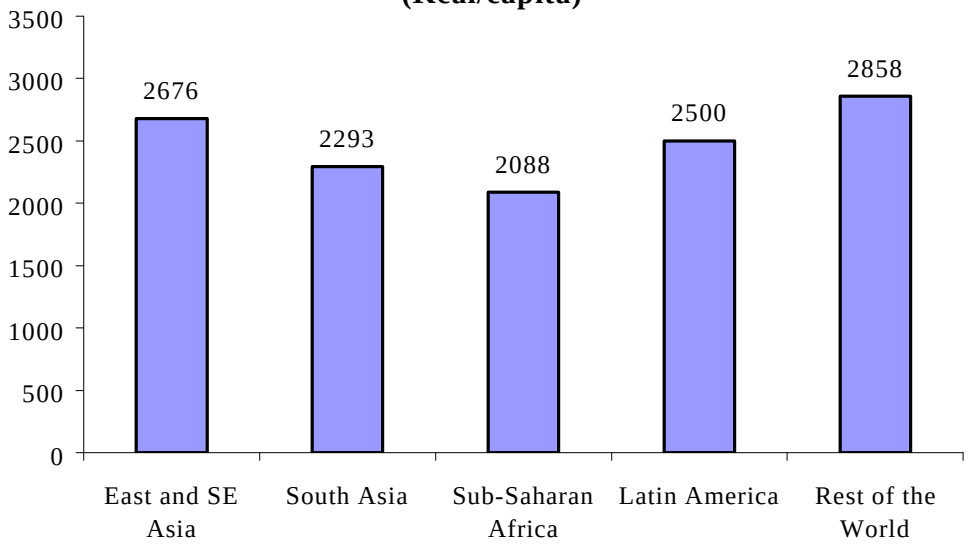
One result is a failure of data on food availability (DES) to accurately predict the extent of undernutrition in South Asia.

In sub-Saharan Africa, on the other hand, the problem is much more one of low levels of food availability and low per-capita real GDP, especially in the war-torn and least developed countries. Poverty results from the fact that there is little wealth or income to distribute, compounded by inequality in distribution and lack of human capital. Education and health are critical problems, due more to low levels of real GDP than to discrimination against women and people living in rural areas. Outside of southern Africa, which is facing the worst of the HIV/AIDS pandemic, generally low levels of population density make African populations somewhat less likely to suffer the health problems posed in South Asia by lack of safe water and sanitation.[9]

The region of East and Southeast Asia is characterized generally by high levels of food availability, relatively high per-capita real GDP, and low levels of poverty in relation to other regions. Women's education and social status are generally better, and there is greater access to safe water and sanitation. Furthermore, the evidence suggests that undernutrition is decreasing in this region, both absolutely and in relation to the total population. Thus, the problems in this region are more those of a few specific countries that have yet to partake fully in the growth process than of dealing with widespread undernutrition on a regional scale. Although many of the Asian economies were weakened by financial crisis in the late 1990s, these problems only mildly affected those countries' prospects for making a major long run impact on undernutrition (IFPRI, 1998)

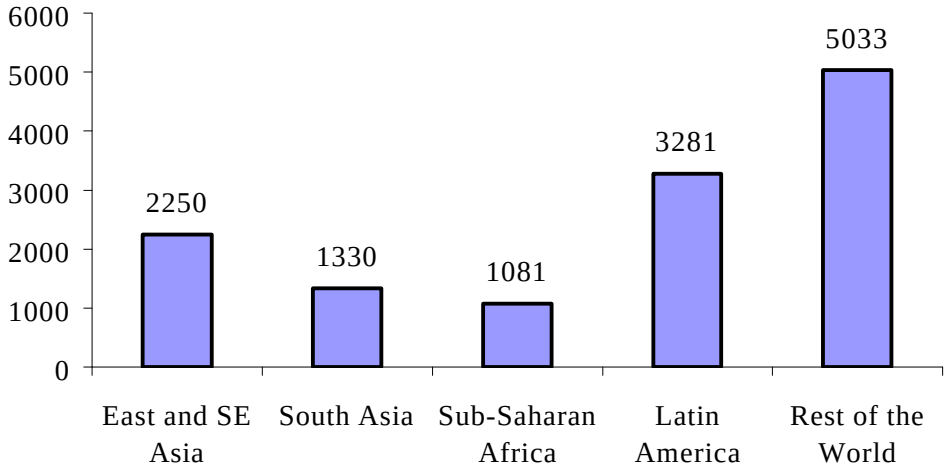
[9] Africa, of course, does have major health problems associated with AIDS, malaria, and parasitic diseases.

Figure 3
Dietary Energy Supply
(Kcal/capita)



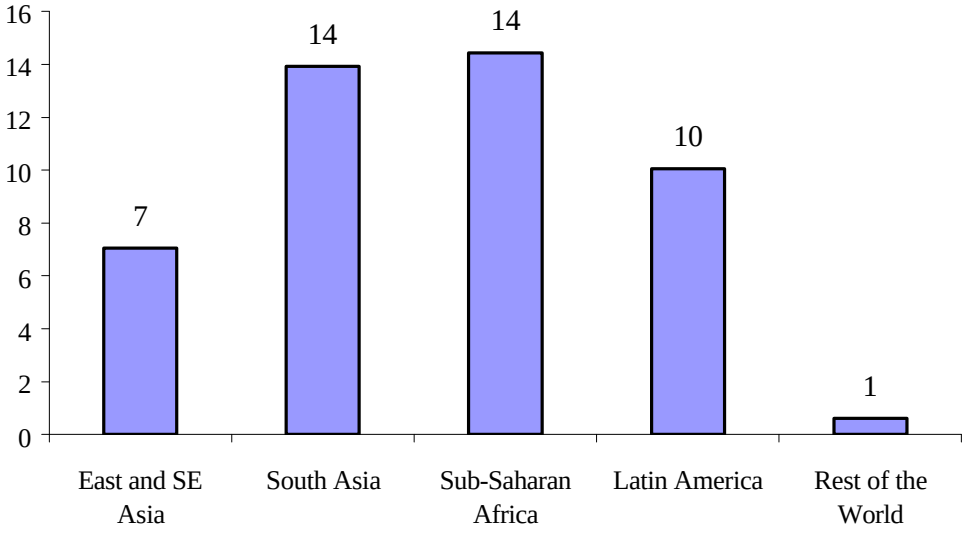
Source: FAO (1996).

Figure 4
Income Per Capita
(1985 U.S. $)



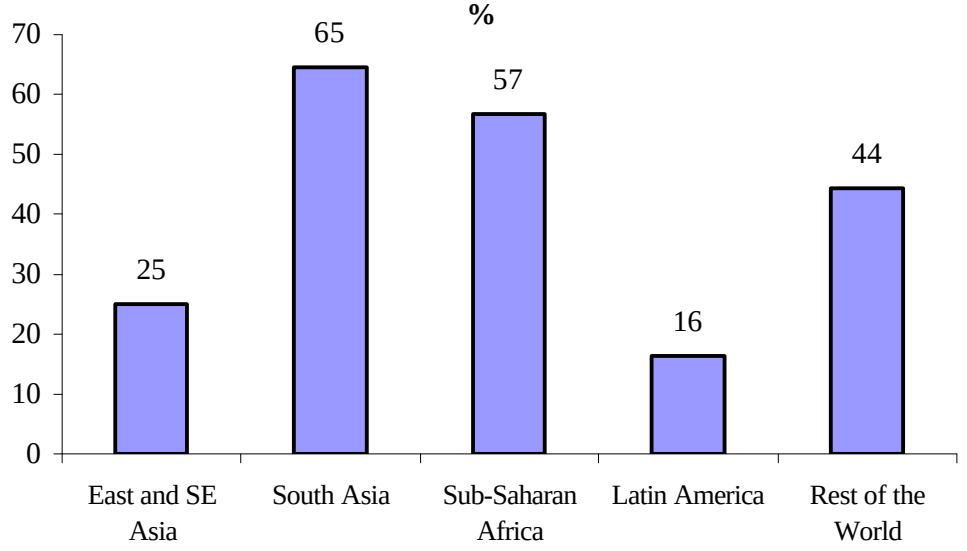
Source: World Development Report.

Figure 5
Poverty Gap
(cents per day per capita, 1985 U.S. $)

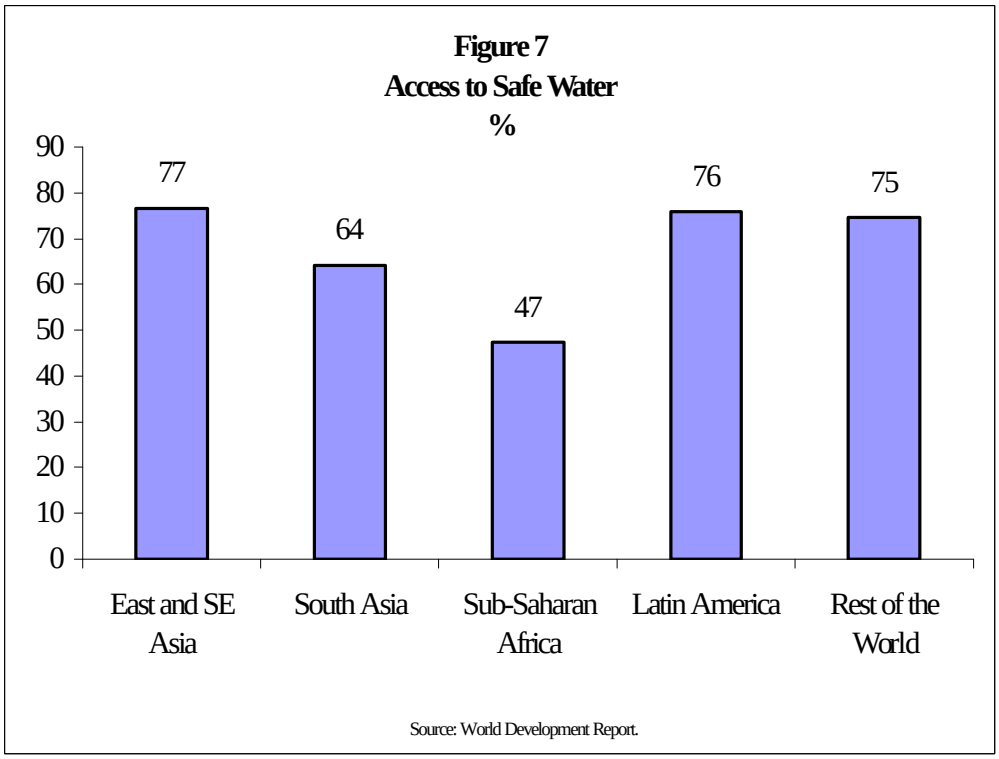


Source: World Development Report.

Figure 6
Female Illiteracy Rate
%



Source: World Development Report.



In Latin America and the Caribbean (LAC) and in the Rest of the World, the picture is one of generally adequate food availability, on a par with East and Southeast Asia. Per capita income is much higher than in the other developing countries, but the poverty gap in LAC is considerably higher than would be expected from this average income level, suggesting the possibility of important pockets of undernutrition. In addition, although female illiteracy is relatively low in LAC, it is quite high in the Rest of the World category, much of which represents North Africa and the Middle East, indicating the possibility of undernutrition within households.

These regional differences in the nature of undernutrition must be addressed in any realistic strategy for meeting the World Food Summit target. The absolute number suffering undernutrition varies by region, as do the expected tendencies until 2015 in the absence of additional intervention by the OECD donors and others. Without additional intervention, some regions are expected to improve on their own as the contribution of food availability and education, resulting in better utilization of resources, grows at a rate faster than population growth. But other regions are expected to continue to worsen in both absolute and relative terms. The main emphasis will therefore be needed in the lagging regions, e.g. sub-Saharan Africa and parts of South Asia.

Consequences and Opportunities

The consequences of the high levels of undernutrition that exist in the world are severe. Above all, they are severe for the more than 800 million people that presently suffer from chronic hunger. Aside from their physical distress, these people are less able to work, reducing the

income they can earn for themselves and for the nation. They are more vulnerable to diseases such as HIV/AIDS or malaria. Poverty and undernutrition thus play upon one another in a vicious cycle that has a number of adverse results.

First, this vicious cycle can lead to political and military crisis. There is substantial evidence that even if poverty and undernutrition are not the proximate causes of these crises, they are often at least contributing factors (Messer, Cohen, and D'Costra 1998, OECD 1998). Furthermore, the cost of dealing with crisis is often far higher than what would have been necessary to avert the crisis in the first place. This topic is treated more thoroughly below in the section on benefits.

Second, chronic undernutrition creates conditions of uncertainty regarding emergency food aid. Where large numbers of people are already suffering from undernutrition, the margin for error in dealing with the consequences of drought, war, and other disasters is comparatively slim. As the world moves away from food aid drawn upon surplus stocks and towards food aid viewed primarily as a budgetary expenditure, this leads to greater uncertainty regarding the fiscal and logistical requirements of emergency food shipments.

Third, poverty and undernutrition feed upon one another in ways that limit the development of local markets for food. This decreases the reliability of markets in these countries for exports from the food-surplus countries, including the United States. As production continues to increase in food exporting countries at rates faster than the growth of domestic consumption, these countries must rely increasingly on the expansion of markets in developing countries. The world has yet to find satisfactory solutions to the disincentives to agricultural research and production facing the most food-insecure countries, which makes the world potentially more vulnerable to global food shortages.

Finally, the vicious cycle of poverty and undernutrition sets back the spread of democracy and good governance to the developing nations. People who are hungry, unproductive, and deprived have a difficult time looking out for their own interests. This encourages corruption, lack of transparency, and poor governance.

The establishment of the Food Summit target presents a unique opportunity to act effectively to break this vicious cycle. The target is visible, measurable, and attainable. It can be achieved, as this report demonstrates, without enormous financial sacrifice.

The moment is appropriate because of a confluence of factors. First, the U.S. agricultural community has developed a strong global perspective regarding its own self-interests. Gone are the days when this community pressed for high domestic prices and accumulation of food stocks. Today, U.S. agriculture is primarily interested in stimulating overseas demand for U.S. farm products. To cut world hunger in half, production agriculture must continue to thrive in the developed countries, but there must also be actions to promote production agriculture in developing countries, raising incomes and liberalizing markets for food in ways that improve household food security and nutrition.

Second, the policy environment in many developing countries has improved enormously since the mid-1980s. Trade and exchange rate policies are more open, trade taxes have been lowered,

fiscal deficits have been reduced, markets have been freed up, and legal and regulatory environments are more conducive to private sector investment and productive activity. This means that interventions to increase food security through productive investments that may have failed 15 years ago are much more likely to succeed today. Nevertheless, the long decline in agricultural investment has not been reversed and there remain substantial biases against developing country agriculture in general and the small farmer in particular.

Finally, the world is currently experiencing, at the global level, a period of relative peace and prosperity that has not existed for almost a century. Despite localized economic crises in Asia and elsewhere and ongoing wars and other conflicts in Africa, in most of the world, lower expenditures for national defense and unprecedented economic prosperity create the best opportunity in at least a hundred years to do something significant about world hunger.

Levels of Interventions

There are a number of different levels at which interventions can be undertaken to alleviate hunger and undernutrition. These levels may be global, national, sectoral, or household. Some examples are illustrated in Table 1. While many other types of interventions could be included in this framework as chosen independent variables, the choice of variables and their model specification is based on empirical evidence suggesting links to reducing undernutrition.

Table 1 : Theoretical Framework for Interventions to Reduce Undernutrition

Levels of Intervention	
What is needed	How to achieve it
Global	
Secure access to food in world markets	International agreements
Peace and physical security	Conflict prevention and recovery
National	
Promote democracy in rural areas	Civil participation and advocacy
Enabling environment	Macro, and trade and legal reform
Sectoral	
Rural production and marketing infrastructure	Public investment in roads
Increase farm productivity	Private technology transfer and public agricultural research
Household	
Raise entitlement to food	Targeted food aid
Empower women	Women's education
Improve rural health conditions	Safe water and sanitation

At the global level, it is important that sufficient food be produced to feed the world's population adequately. It is also important that global markets and other institutions operate effectively to permit food to move reliably from areas of surplus to areas of deficit. This requires a host of international agreements and other reform measures, such as further agricultural trade

liberalization under the World Trade Organization, to strengthen household food security and nutrition.

Global actions must also help ensure that there is peace and a high degree of physical security in these countries and regions afflicted by undernutrition if food supplies are to be transported safely within the country and if stocks of food are to be secure. This requires conflict prevention and resolution whenever possible. Where conflicts do arise, their speedy resolution and the economic recovery of the countries concerned should be a high priority. Research shows that the undernutrition resulting from war and civil strife is high and that the costs of dealing with it through emergency food aid are also high (Messer, Cohen, and D'Costa 1998).

Interventions at the national level include the promotion of democracy in rural areas and the creation of an enabling environment for trade and investment. Quite simply, "democracy reduces poverty" (Bread for the World Institute, 2001). The promotion of democracy through civil participation and advocacy can be important in creating the conditions for the sustainable use of natural resources, especially those that are of a collective nature. This helps to increase the availability of food. Effective political advocacy also helps to ensure that the rural population receives its fair share of rural infrastructure, such as roads, irrigation works, schools, health facilities, and safe water and sanitation. This can have an important influence on agricultural productivity, education, and health, all of which favorably influence nutrition.

Research has shown that a policy environment opened to international trade and investment is important for higher rates of economic growth (Sachs and Warner, 1996), which in turn raises national and rural incomes. The result is increased availability of and access to food, more education for women, and better access to safe water and sanitation, all of which reduce undernutrition. In addition, countries can benefit by reducing trade taxes and other barriers to food imports, actions that lower food prices and increase real incomes used to purchase food.

At the sectoral level, the two most important types of interventions are investment in productive rural infrastructure and in agricultural research, extension, and education. These increase agricultural productivity, which in turn raises national income through a multiplier effect. The result is both a direct contribution to food availability through increased food production and an indirect increase in food availability, women's education, and safe water and sanitation because of higher national income. All of this serves to improve nutrition.

At the household level, the most effective way of improving nutrition is to direct interventions towards women.[10] One approach, which has been used quite successfully in a number of countries under Title II food aid, is to channel resources through local projects such as maternal and child health programs. Part of these resources can be monetized to pay not only for health care but also for nutritional education, functional literacy programs, family planning, improved access to safe water and sanitation, promotion of small-scale agriculture, and direct income transfers. In addition, some of the aid can be channeled to participants directly in the form of food assistance. Finally, investment in women's education, especially at the secondary school level, has been shown to have important nutritional benefits (Smith and Haddad, 1998).

[10] There is extensive literature on the nutritional benefits of women's status, education, and control over resources within the household. See, for example, Rogers and Schlossman (1990).

Costs of Achieving the Target

In order to estimate the costs of achieving the Food Summit target of reducing the number of undernourished to 400 million by the year 2015, empirically derived parameters were used to link the interventions discussed above to resulting declines in undernutrition. The cost of each intervention, presented in detail in Annex A, was then multiplied by the scale of the intervention in order to derive total costs for that intervention.[11] Four scenarios were then developed using different combinations of these interventions to achieve the Food Summit target, assuming that the interventions are incrementally added to the baseline interventions assumed in the projections discussed earlier and that they are for the most part financed by the donors.

The countries and sub-regions for which these calculations were made are China, Indonesia, Rest of East and Southeast Asia, Pakistan, India, Bangladesh, Rest of South Asia, Nigeria, Ethiopia, War-Torn sub-Saharan Africa (minus Ethiopia), Least Developed SSA, Developing SSA, Latin America and the Caribbean, and Rest of the Developing World. Because of higher levels of per capita income and lower levels of undernutrition in Latin America and the Caribbean and in the Rest of the World, it was assumed that interventions in these regions would be financed by the countries themselves rather than by the donors, and these costs do not appear in the totals. The sole exception to this is technical assistance for policy change, which was assumed to be financed by the donors.

Scenario 1: Equal Distribution

As with all the scenarios, the first scenario assumes that, in addition to securing access to food in world markets, all three of the other policy interventions at the global and national levels -- reducing war and civil strife, increasing democracy, and creating an enabling environment for trade and investment plus reducing barriers to food imports -- are achieved through a combination of international pressure and incentives plus technical assistance and training at the national level. Only minimal costs have been estimated for reducing war and civil strife. These comprise the costs of engaging conflicting parties in a sustained dialogue that results in resolution of the conflict. It is assumed that this will remain an important goal of donor country foreign policy, but it is impossible to estimate any additional costs involved in order to assure success in reducing conflict. However, it is assumed that other interventions cannot be carried out as long as there is a significant level of physical insecurity so that progress must be made in the war-torn countries if undernutrition is to be reduced. For interventions at the sectoral and household levels, the same level of funding is assumed for each person in a state of undernutrition in each country and sub-region, and the funds are distributed equally among the interventions, which include:

- construction of rural roads
- agricultural research and extension
- monetized food aid for social sector and community nutrition programs
- female education
- improved access to safe water

[11] In some instances, the relationship between unit cost and scale is nonlinear, as described in Annex A.

As in any estimation exercise, there are a host of external factors that could substantially change the costs of actually undertaking the intervention. For example, every donor has experience with projects hindered by natural and manmade disasters, problems with sequencing, corruption, poor targeting, or lack of local commitment. Gaining political will – whether in donor or partner countries – also has its costs. None of this is factored in because of the difficulties of estimation.

The results of this scenario are presented in Table 2. They show that the **total cost of achieving the Food Summit target under this scenario is $125 billion**, with the largest amounts spent in Asia because most undernutrition is concentrated there.

Table 2: Impact of Interventions on Undernutrition (Millions of People)
Scenario 1: Equal Distribution

		East & South East Asia	South Asia	War torn SSA	LDC SSA	Devel-oping SSA	Latin America	Rest of World	Total # million people	Total Cost (Million dollars)
National Political Policy										
Reduce war		-1	-1	-7	0	0	0	-2	-11	4,801
Increase democracy		-1	-1	0	0	0	0	0	-3	1,630
National Economic Policy										
Open trade		-5	-11	-1	0	-1	0	-3	-21	1,933
Reduce food tariffs		-15	-5	-7	-4	-7	-1	-8	-48	
Sectoral Policy										
Rural roads		3	2	-1	1	0	0	0	6	23,255
Agricultural research		-31	-79	-18	-6	-9	0	0	-142	23,255
Household Policy										
Targeted transfers		-66	-58	-9	-2	-5	0	0	-139	23,255
Female literacy		-15	-75	-9	-3	-4	0	0	-106	23,255
Safe water		-3	-10	1	-1	-1	0	0	-14	23,255
Own resources		0	0	0	0	0	-15	-25	-40	0
Total Reduction in Undernutrition		-133	-237	-51	-15	-27	-17	-38	-518	
Total Cost	**Million $**	**30,051**	**65,989**	14,888	4,655	7,263	434	1,361		**124,641**

Although this scenario may be *equitable,* it is not very *efficient* in achieving the target. Table 3 shows the cost per person removed from the list of those suffering undernutrition by country/region and type of intervention under the equal distribution scenario. These are marginal costs, based on both the cost of an increase in each intervention and its effectiveness in reducing the number of those suffering from undernutrition.

Of the sectoral and household interventions, for which costs have been estimated directly, the *least* cost-effective for South Asia and sub-Saharan Africa are (1) construction of rural roads and (2) investment in safe water delivery.[12] It is recognized, moreover, that these have important interactive effects with other variables. For example, the success of agricultural research depends on at least a minimum level of road infrastructure. Furthermore, access to safe water, whose contribution to improved nutrition is limited by the relatively comprehensive coverage

[12] Construction of roads is more cost effective in the least developed countries of SSA than elsewhere because the road density there is so low that the impact on agricultural productivity would be considerably greater than in other countries. This is because the model has substantial diminishing returns built into this intervention.

that exists already, interacts with increased food availability and women's education. These interactive effects are taken into account in the third scenario, which achieves a balance between the different interventions, but in a relatively cost-effective way.

Technical assistance in support of economic policy reform is very cost-effective in countries where reform is needed. Many of the countries and regions of Table 3 have very high rates of trade protection on food in order to encourage domestic production. Although this results in some increase in local production, the cost to consumers is high. Simply removing this protection would go a considerable way towards decreasing undernutrition as a result of the ensuing decline in food prices. It is assumed here that *governments are already committed to reform* so that the only additional costs incurred are those associated with providing technical assistance to support their efforts. The same is true of democratization, except that its influence on undernutrition is considerably weaker than that of economic policy reform, which has a more important effect on economic growth.

Table 3: Cost Effectiveness of Interventions under Equal Distribution Scenario ($/per capita reduction in undernutrition)

	East & South East Asia	South Asia	War Torn SSA	LDC SSA	Devel-oping SSA	Latin America	Rest of World	Total
National Political Policy								
Policy costs: Pol.Stability	408.47	564.91	382.27	N/A	N/A	1277.55	512.79	437.69
Policy costs: Democrat.	719.26	328.20	562.55	817.46	974.60	1936.83	777.42	601.39
National Economic Policy								
Policy costs: Trade/Macro	24.23	41.60	28.91	25.60	28.62	36.30	12.41	27.84
Sectoral Policy								
Rural roads	1660.82	5660.60	4503.15	807.27	5862.20	N/A	N/A	3842.16
Agric. Research	183.16	164.48	133.33	157.62	150.55	N/A	N/A	163.51
Household Policy								
Targeted food aid	85.92	223.15	267.52	574.61	293.59	N/A	N/A	166.85
Female education & status	391.06	172.75	262.97	264.22	350.78	N/A	N/A	220.04
Safe water	1864.66	1273.16	2372.09	1631.48	1382.00	N/A	N/A	1691.96

N/A: not applicable because equal distribution scenario results in none of this intervention in region indicated.

Agricultural research (and to a lesser extent, agricultural extension and education) is quite cost effective in reducing undernutrition in East and Southeast Asia, South Asia, and most of sub-Saharan Africa. Targeted food aid is also relatively efficient in most countries. The critical assumption here is that the total level of assistance is sufficient to move at least one-half the poor above the poverty line, assuming a capital-to-output ratio of 4:0. That is, targeted food aid investments can be undertaken for a sum that equals a capital investment of four times the desired output of one-half the level of the poverty gap. While a direct income transfer may only require a capital-to-output ratio of 1:0, this will only lift the beneficiaries out of poverty for only one year. It is assumed that a ratio of 4:0 will enable the beneficiaries to remain above the poverty line indefinitely.

Another intervention that is very cost effective is investment in women's education, especially at the secondary school level. This has an important effect on the allocation of food within the

household and on women's status. It also helps to raise the level of household income, benefiting all members of the household.

This report has incorporated a substantial increase in the cost of interventions that influence labor productivity and women's education due to the drag caused by HIV/AIDS in Africa. In the worst affected regions of southern Africa, for example, up to 26% of the agricultural labor force will be wiped out (FAO 2001).

Scenario 2: Least Cost Distribution

Based on the indicators of cost-effectiveness shown in Table 3, a least-cost distribution of interventions is set out in Table 4 as Scenario 2. Assistance in the reduction of war, democratization, and economic policy reform is assumed to remain at the same level as in Scenario 1. This is because these reforms are considered essential to the success of reforms at the sectoral level. Only those reforms carried out at the household level can be presumed to be successful in the absence of physical security, a reasonable level of democratic governance, and an enabling economic environment.

Table 4: Impact of Interventions on Undernutrition (millions of people)
Scenario 2: Least-Cost Distribution

	East & South East Asia	South Asia	War torn SSA	LDC SSA	Devel-oping SSA	Latin America	Rest of World	Total # million people	Total Cost (Million dollars)
National Political Policy									
Reduce war	-1	-1	-7	0	0	0	-2	-11	4,801
Increase democracy	-1	-1	0	0	0	0	0	-3	1,630
National Economic Policy									
Open trade	-5	-11	-1	0	-1	0	-3	-21	1,933
Reduce food tariffs	-15	-5	-7	-4	-7	-1	-8	-48	
Sectoral Policy									
Rural roads	0	0	0	0	0	0	0	0	6
Agricultural research	-10	-83	-15	-5	-10	0	0	-124	21,002
Household Policy									
Targeted transfers	-63	-111	-5	0	-4	0	0	-182	28,931
Female literacy	-7	-75	-5	0	-1	0	0	-89	14,116
Safe water	0	0	1	0	0	0	0	1	34
Own resources	0	0	0	0	0	-15	-25	-40	0
Total Reduction in Undernut	-101	-287	-40	-10	-24	-17	-38	-517	
Total Cost Million $	**$10,900**	**$48,446**	$6,873	$1,152	$3,286	$434	$1,361		**$72,452**

At other levels, investments in rural roads and in safe water are virtually abandoned, and resources are reallocated not only towards other interventions but also marginally towards South Asia to the detriment of most other regions. The result is a substantial reduction in the cost of achieving the target from $125 billion to **$72 billion under the least-cost scenario**. However, a very large part of the nutritional gain comes from investments in agricultural research and female education, as well as targeted transfers, in South Asia. The former may be less than totally realistic given the fact that yields are already at moderate levels. However, there is still substantial room for yields to increase, and there may be even further potential for increases in

labor productivity associated with mechanization as agriculture modernizes.[13] As far as women's education is concerned, investment in South Asia has a particularly high payoff in reducing undernutrition. The cost associated with providing women's education and improving women's status is higher in Africa than in South Asia, partly due to the impact of HIV/AIDS. This means that it is more cost-effective to educate the women of South Asia in order to reach the target of 400 million undernourished in 2015.[14] Thus, this scenario is quite cost-effective but lacks elements of equity.

Scenario 3: Rational Distribution: Efficiency with equity

A third scenario was developed in which sub-Saharan Africa is stressed to a much greater extent. This scenario is presented in Table 5. Heavy emphasis is placed on war-torn SSA, where substantial gains in nutritional status are possible at only moderate costs. Interventions in SSA are also strongly oriented towards agricultural research, female education, and targeted transfers, which are the most effective ways of reducing undernutrition. The cost of this scenario is **$80 billion**, or about 11% higher than Scenario 2. Further shifts towards Africa could also be undertaken without raising costs too much further.

Table 5: Impact of Interventions on Undernutrition (millions of people)
Scenario 3: Rational Distribution

	East & South East Asia	South Asia	War torn SSA	LDC SSA	Devel-oping SSA	Latin America	Rest of World	Total # million people	Total Cost (Million dollars)
National Political Policy									
Reduce war	-1	-1	-7	0	0	0	-2	-11	4,801
Increase democracy	-1	-1	0	0	0	0	0	-3	1,630
National Economic Policy									
Open trade	-5	-11	-1	0	-1	0	-3	-21	1,933
Reduce food tariffs	-15	-5	-7	-4	-7	-1	-8	-48	
Sectoral Policy									
Rural roads	0	-1	-1	0	0	0	0	-2	1,492
Agricultural research	-12	-63	-29	-10	-12	0	0	-126	19,339
Household Policy									
Targeted transfers	-71	-81	-14	-2	-6	0	0	-174	31,286
Female literacy	-5	-75	-7	-3	-2	0	0	-92	19,876
Safe water	0	0	1	0	0	0	0	1	126
Own resources	0	0	0	0	0	-15	-25	-40	0
Total Reduction in Undernut	-109	-237	-66	-20	-29	-17	-38	-517	
Total Cost Million $	**$12,256**	**$44,068**	$13,396	$4,267	$4,701	$434	$1,361		**$80,483**

[13] It is sometimes asserted that there is little scope for further increases in agricultural production in South Asia because most of the opportunities for improvement have already been exploited on good land and the opportunities that exist on poorer land are much less. This is contradicted for India, however, by the relatively high returns found to use of high yielding varieties and other interventions in areas of so-called low potential (Hazell and Fan, 1998).

[14] This result assume that HIV/AIDS will not spread in South Asia to the same extent that it has in Southern Africa, an assumption that may or may not be realistic.

Scenario 4: Policy Absent

The last Scenario, shown in Table 6, looks at what could be done with household investments if there were no progress in reducing war, democratization, or economic policy reform. Under these conditions, investment in roads or agricultural research would be relatively ineffective since conditions would not be ripe to benefit from these investments. Nevertheless, interventions could be attempted at the household level with respect to targeted food aid, female education, and access to safe water, though in the absence of physical security even these would be difficult to implement. As the table shows, however, this scenario, even if it worked in meeting the Food Summit target, would be quite expensive at $126 billion.

Table 6: Impact of Interventions on Undernourished (millions)
Scenario 4: Policy absent

	East & South East Asia	South Asia	War torn SSA	LDC SSA	Devel-oping SSA	Latin America	Rest of World	Total # million people	Total Cost (Million dollars)
Household Policy									
Targeted transfers	-142	-166	-25	-4	-12	0	0	-349	61,912
Female literacy	-15	-75	-9	-3	-4	0	0	-106	39,315
Safe water	-2	-10	1	0	0	0	0	-12	16,835
Own resources	0	0	0	0	0	-14	-38	-40	0
Total Reduction in Undernut	-159	-251	-33	-8	-16	-14	-38	-518	
Total Cost **Million $**	$24,976	$73,323	$15,100	$4,734	$6,497	$434	$1,361		**$126,425**

Conclusions

The analysis in this section has shown that if no additional action is taken, world undernutrition will increase in absolute terms by the year 2015. Instead of being 400 million, which would meet the target, it will be more like 900 million. Yet, there is a unique opportunity for the donors, including the United States, to exercise global leadership in meeting the Food Summit target without incurring enormous expenditures. The report has demonstrated that there is a viable and affordable strategy that exists for achieving this goal. Under Scenario 3, the "rational" or "efficiency with equity" scenario, the donor share of the additional annual costs would be about $6 billion per year, or around 11 percent of the current level of official development assistance. The particular strategy that would be most effective, aside from the necessary preconditions of global and national political and economic policy, is for the donors to concentrate efforts on South Asia and sub-Saharan Africa, especially in the areas of agricultural research, health and agricultural programs targeted at women, and women's education. This strategy could draw heavily upon the experience of U.S. farmers, agribusiness, NGOs, universities, foundations, churches, and the U.S. government.

BENEFITS FROM MEETING THE FOOD SUMMIT TARGET

The previous section of this report estimated that the cost of meeting the World Food Summit target would be within the range of $72-$126 billion over the next 13 years, with the most rational strategy costing about $80 billion, or a little over $6 billion per year. The section concludes that the most cost-effective way to meet the Food Summit target is a strategy in which the donors concentrate their interventions, beyond those already being undertaken, in South Asia and sub-Saharan Africa, where most of the food insecure are found. However, South Asia and sub-Saharan Africa (SSA) present very different types of problems. In SSA, food insecurity is due primarily to the low level of food availability relative to need. In South Asia, on the other had, the problem is more one of distribution and utilization. Highly unequal incomes, low status of women, and poor water and sanitation in a monsoon climate result in more undernutrition than does simple availability.

One question that has been raised is the extent to which improving food security has benefits as well as costs. Clearly, the most important benefits are to those who are no longer hungry, who are now able to work and live productively and to develop to their full potential. Some of these benefits can be measured, particularly those related to enhanced productivity. Others linked directly to improved human welfare are more difficult to measure, and we do not attempt to do so here. Rather, we confine ourselves to benefits that are more readily measured, with some focus on those that result in less demand on the donors.

This does not imply that the donors will reduce their assistance in response to these savings. Rather, it means that resources can be more effectively allocated for sustainable development and poverty reduction. For example, there is substantial evidence that low levels of agricultural production and per capita income tend to encourage civil conflict, which in turn results in further impoverishment of the local population. By investing in agriculture before conflict ensues, the donors are able to reduce the costs of peacekeeping and humanitarian assistance, and to devote more of their assistance to development.

This section of the report address these issues by estimating some of the benefits of reduced undernutrition that are related to a decline in the cost to the donors of humanitarian assistance and peacekeeping operations associated with civil conflict, a reduction in the cost of public health, a decrease in the cost of treating HIV/AIDS, and increased income resulting from an increase in agricultural productivity. A final sub-section assesses the impact of greater income in poor countries on their demand for agricultural exports from the donor countries, particularly the United States.

Food Security, Income, and Civil Conflict

This sub-section first estimates the ongoing cost to the donors of peacekeeping operations and humanitarian assistance. It then assesses the extent to which increased agricultural production would result in a reduction in conflict and in a saving of these costs. The report benefits from some very recent empirical work, which has shown that both the prevalence and the duration of civil conflict are strongly correlated with the level and rate of growth of per capita income. By relating increases in agricultural production to national income, we can see the degree to which

the cost of improved food security is at least partially offset by the benefits associated with reduced conflict.

The analysis is focused particularly on sub-Saharan Africa because it is here where the problem of civil conflict arising out of poverty and food insecurity is most prevalent in terms of the numbers of food insecure who are likely to be affected. In South Asia, by contrast, the very large number of people who are undernourished live in areas in which there is little civil conflict. Another reason for focusing on Africa is that it is here where the problem of food insecurity can best be solved by donor contributions to increasing agricultural production. In South Asia, on the other hand, the problems are related more to improving the distribution of income and enhancing the status of women, two areas in which the donors are likely to have less of an influence no matter what level of assistance they offer.

The next sub-section of the paper discusses the association between civil conflict and low incomes in terms of the experience of individual countries and the hypotheses that can be drawn from this experience. It also draws together the results of several empirical investigations that quantify, albeit in a relatively rough way, some of these relationships. After this, the costs of civil conflict are estimated as those related to emergency and distress relief, developmental food aid, peacekeeping operations, and refugee assistance. Based on the parameters obtained from the empirical studies on the links between conflict and income, the benefits resulting from reduced undernutrition are assessed.

Conflict Based on Low Income

The vast majority of conflicts in the world in the 1990s took place within the national borders of the world's poorest countries in Asia and Africa. Sollenberg and Wallensteen (2000) have tracked armed conflict around the world since 1989. Of the 110 conflicts they note for the entire period, 94 were intrastate, 9 were intrastate with foreign intervention, and 7 were interstate. By region, the highest number of conflicts occurred in Africa and Asia over the period. By 1999, there were 14 armed conflicts in Asia and 15 in Africa, with a trend towards more new conflicts in Africa relative to Asia.

Although Wallensteen and Sollenberg (2000) do not distinguish among those conflicts that have their origins in food insecurity and those that do not, others have used their data to note a high correlation among areas in conflict and areas that are economically dependent on agriculture. DeSoysa and Gleditsch (1999), for example, correlate armed conflicts with a high dependence on agriculture. Approximately 100 major and minor conflicts -- distinguished by single years in which more than 1000 deaths occurred (major) or 500 deaths occurred (minor) -- took place almost exclusively in countries in which the share of GDP generated by agriculture surpassed 11.3%. They also occurred in the areas of the world known to be poorest and least food secure: South Asia, Africa, Central America, and the western nations of South America.

The correlation between food insecurity and civil conflict may be misleading. Some authors have tested the hypothesis that armed conflict results from low levels or rates of growth of per capita income. For example, Collier and Hoeffler (1998), basing their analysis on utility theory, argue that rebels will conduct civil war if the perceived benefits outweigh the costs of rebellion.

The benefits depend on the potential tax revenue that can be raised if the rebellion is successful. This in turn depends on the potential tax base, which is a function of the natural resource base and the level of per capita income of the population. However, a higher tax base also enhances the capacity of the existing government to put down the rebellion and thus reduces the probability of the rebels' winning. Major costs to the rebels are the opportunity cost of their labor and the cost involved in the disruption of their livelihoods, each of which rises with increased per capita income.[15]

One finds, in fact, a remarkable coincidence between the level of per capita national income and the kinds of civil conflicts referred to as complex emergencies. Complex emergencies are human-made, and are thus distinguishable from unanticipated natural disasters (Väyrynen, 2000). They involve a nexus of mutually reinforcing factors that may include political conflict, food insecurity, low incomes, displacement, adverse climatic conditions, anarchy, and lack of state authority. These emergencies are rarely found in high-income countries (Nafziger and Auvinen, 2000, p. 95). The absolute level of deprivation is an important cause of these conflicts, since people are so deprived that they have little to lose. Protracted stagnation may also present opportunities for local elites to appropriate the assets and resources of weaker social groups, thus increasing the overall level of antagonism and social discontent.

Another reason why people with low incomes are willing to wage war is that they have a feeling of relative deprivation. This may occur because they become aware of the fact that others are better off, or they may experience relative deprivation in terms of their own past income if there has been a decline in that income. This can occur even when there is little absolute deprivation (Nafziger and Auvinen, 1999, pp. 102-05).

Africa is currently experiencing the aftermath of slow or negative economic growth in many countries during the 1970s, 1980s, and early 1990s. This has made it more difficult to support the ruling elite and has threatened political cohesion. Elites have responded by forming new patterns of clientage in order to maintain their legitimacy. These personalized relationships between patrons and clients frequently have undermined political and economic institutions that cut across ethnic and regional lines, thus forming the basis for entrenched inequality of wealth, status, and influence. In some cases, a predatory state has ruled though coercion, material inducement, and personality politics "to plunder the national economy through graft, corruption, and extortion." This implies, effectively, that the state had been privatized (Nafziger and Auvinen, 1999, pp. 111-14).

Aside from its impact on food security, the failure of agriculture has been a major factor influencing the decline in income and resulting social and political disintegration. In most poor countries, agriculture employs up to 70 percent of the population and accounts for a large part of GDP. Furthermore, agriculture has a major influence on the rest of the economy through its contribution to food supplies, foreign exchange earnings, and transfers of labor and capital. Declining productivity in agriculture not only contributes directly to conflict situations but also may spur rural-urban migration, leading to increasing urban unemployment and fostering political discontent (Nafziger and Auvinen, 1999, p. 117).

[15] Elbadowi and Sambanis (2000) also emphasize the role of per capita income in increasing the opportunity cost of rebel labor.

Cornia, Jolly, and Stewart (1987) have shown how declining real income among poor households contributes to reduced food availability, decreased nutrient intake, and increased malnutrition and disease. Between 1962 and 1989, food output per capita in Africa declined at an annual rate of 0.8%. Despite rising food imports, much of it in the form of food aid, daily calorie consumption in 1988-90 was 2,116 kcal, the same as it was in the early 1960s, and only 92% of the requirement set by FAO. By 1996-98, it had only risen to 2200 kcal, considerably lower than South Asia's 2420 kcal (Committee on World Food Security, 2001). Average calorie consumption in all other regions of the world, on the other hand, exceeded the FAO requirement. (Nafziger and Auvinen, 1999, p. 117-18)

This stagnation of agricultural productivity was at least partially rooted in the political situation. Following independence, Africa's governing elite based their power to a large extent on the political support of urban elites and workers. In rural areas, political support was gained by expanding patronage through estate agriculture, dominated by a few elite, and by providing subsidies and other benefits to selected project participants. This was preferred to the use of pricing policies and construction of rural infrastructure, which would have benefited smaller farmers much more but would not have provided opportunities for political patronage. To the extent that price and exchange rate policies were used, they tended to be biased towards urban areas, as were social expenditures on health and education.

One of the major problems in rural areas is lack of access by poor small farmers to markets, infrastructure, credit, technology, and social services. Recent evidence points, for example, to the importance of non-farm rural activities as a substantial source of income and growth for part of the rural population. However, there are significant barriers to entry, so that the poor do not participate (Barrett, Reardon, and Webb, 2001). The result is widening disparities in income and wealth, creating an environment for civil disturbance. In this situation, the state may begin to act in a repressive fashion, trying to stamp out rebellion before it gathers momentum. But this frequently further exacerbates the situation by sharpening the differences between conflicting parties.

Quantifying these Effects

There are a number of recent studies that empirically link levels or rates of growth of per capita income with their impact on civil conflict. Collier and Hoeffler (1998), for example, use probit and tobit regressions to investigate the effect of per capita income, natural resource endowment, population size, and ethno-linguistic fractionalization on the occurrence and duration of civil war, using data on civil wars from 1960 to 1992. A major finding is that high per capita income reduces both the duration of civil war and the probability of its occurrence. For example, around its mean level, a quadrupling of per capita income reduces the probability of civil war from 63% to 15%. The predicted duration of civil war is also much shorter if incomes are higher. Furthermore, although theoretically, per capita income could have both positive and negative effects on the prevalence of civil war, empirically the square of income is not significant. The conclusion they draw is that income is predominantly a proxy for the opportunity cost of labor used in war.

Using a slightly different data set on civil war from 1960 to 1999 in 161 countries, Elbadawi and

Sambanis (2000) examine the impact on the prevalence of civil conflict of per capita income as a proxy for the opportunity cost of rebel labor, openness of political institutions, level of ethnic diversity, level of religious diversity, share of primary exports in GDP, and population size. A major objective is to understand why the prevalence of war in Africa has increased in the last two decades whereas it has fallen or remained stagnant in other regions. It concludes that the median African country can be expected to experience civil war in any five-year period with a probability of 11%. A major reason is the low level of per capita income.

Finally, Auvinen and Nafziger (1999) have applied pooled cross-section time-series regression techniques to a sample of 124 countries over the period 1980-95. The analysis shows that complex emergencies are directly associated with income inequality measured by the Gini coefficient, inflation, military expenditures in relation to GNP, and a tradition of conflict, and are negatively associated with growth of GDP, GNP per capita, food output growth, and IMF funding as a percentage of GNP. These emergencies are most robustly associated with slow or negative economic growth, low per capita GNP, high military expenditures, and a tradition of violent conflict. For example, both a 10% increase in GDP growth and a doubling of GDP per capita reduce the probability of a complex emergency by 13%.

Although growth of food output is negatively associated with the prevalence of conflict, this correlation is barely significant in the regression analysis and is not significant in the probit analysis. This is partly because of the complex interaction of multiple variables as determinants of complex emergencies, which in some cases makes it difficult to single out any particular variable.

> A major factor responsible for the increase in emergencies in the 1990s is the developing world's stagnation and protracted decline in incomes, primarily in the 1980s. Economic decline leads to relative deprivation…[which] spurs social discontent and sometimes anger, which provide motivation for potential collective violence. Poor economic performance undermines the legitimacy of a regime, increasing the probability of a regime turnover. Political élites may use repression to forestall threats…which may trigger further discontent and socio-political mobilization….
>
> A major contributor to slow growth is agricultural stagnation…. A second factor, high income inequality, contributes to regional, ethnic, and class discrepancies that engender crises. A third contributor, inflation, increases popular discontent, especially among low-income classes. A fourth factor, the strategies of political élites in response to [the others], is instrumental in determining the potential for political conflict and humanitarian emergencies.
>
> (Nafziger and Auvinen, 1999, pp. 129-30.)

Despite the complexity of causal effects, it appears that agricultural stagnation has a tendency to lead to armed conflict less because of its direct impact on food security and more because it reduces per capita incomes, which in turn lowers the opportunity cost of engaging in such conflict and increases discontent associated with relative income disparities.

Costs of Civil Conflict

Nature of the Costs

There are numerous costs associated with civil conflict. These include, of course, the direct costs to the participants in terms of death and suffering, the opportunity cost of their labor, the educational sacrifices made, and the general disruption of their lives. There are also enormous costs to innocent bystanders. Beyond that, other countries, especially the donors, are called upon to pay substantial costs associated with humanitarian assistance and peacekeeping operations. It is these costs that concern us here, but one should not forget that the welfare loss associated with these costs is probably much less than that associated with the costs to participants and innocent bystanders.

The cost to the donors of complex emergencies includes emergency food aid and other forms of distress relief, the cost of peacekeeping operations, and refugee assistance. In some cases assistance is provided directly by the donors, often through the intermediation of NGOs. In other instances it is channeled via multilateral organization such as the United Nations.

In addition to the costs to the donors of complex emergencies, it is also increasingly being recognized that civil conflict and its aftermath raises the cost of all humanitarian responses, be they to natural disaster or to complex emergencies. This is because the effects of natural disaster are frequently made much worse by the prevalence of dysfunctional states that are incapable of responding effectively to the disaster even if violent conflict has not yet broken out. Indeed, the state may actually play a predatory role in the face of natural disaster by allocating scarce resources towards its clients rather than to those most in need, which further exacerbates the impact of natural disaster on the population. Indeed, the distinction between natural disaster and complex emergency may be difficult to draw when one considers the role of the state in countries that are very poor and food insecure.

Finally, there is also a linkage between development food aid and civil conflict. Aside from the explicit allocation of some development food aid for humanitarian purposes, most of the rest of this aid is targeted towards those who are poor and most vulnerable. Poverty and vulnerability are made substantially worse by civil conflict, or even by states that have become partially dysfunctional because of low income, lack of tax revenue, regional and ethnic tensions, and other factors normally associated with a pre-conflict situation.

Cost Estimates

Cost estimates for peacekeeping and humanitarian assistance are presented in Table 7. There are a number of sources of data regarding the cost to donors of dealing with civil conflict. The United Nations tracks humanitarian requirements, contributions, and shortfalls on an annual basis for all natural disasters and complex emergencies around the world. [16] The average annual level of assistance reported for natural disasters for 1995-2000 was $443 million. This, however, does not include contributions in kind and services not costed. The average annual level of

[16] United Nations Office for the Coordination of Humanitarian Affairs (OCHA), Reliefweb: (http://www.reliefweb.int), United Nations Consolidated Inter-Agency Humanitarian Assistance Appeals.

assistance during the same period for complex emergencies was $1,369 million. In 2000 alone, this assistance to Africa totaled $594 million, aiding more than 20 million people in Angola, Burundi, the Democratic Republic of Congo (Kinshasa), the Republic of Congo (Brazzaville), Sierra Leone, Somalia, Sudan, Tanzania and Uganda. In Asia, Europe, and Latin America, assistance totaled $779 million, targeting 13 million people spread across Afghanistan, North Korea, Indonesia (East and West Timor), and Southeastern Europe. Donors contributed another $72 million for relief related to complex emergencies in Tajikistan and Northern Caucasus.

Another source of data is OECD/DAC *Development Co-Operation Report.* This provides figures on Bilateral Official Development Assistance, including grants and grant-like contributions in the form of Developmental Food Aid and Emergency/Disaster Relief. The data are provided both for all DAC members and for each individual country, including the United States. These figures are considerably higher than the sum of the OCHA estimates for natural disasters and complex emergencies. Since the natural disasters estimates for OCHA do not include contributions in-kind, and since we know that in-kind food aid is an important component of this assistance, we have provided an alternative estimate of natural disasters assistance by subtracting the OCHA figures for complex emergencies from the OECD/DAC data on total bilateral assistance. This indicates that annual assistance for natural disasters averaged $1,659 million from 1995 to 1999.

The contribution of the United States to Emergency and Distress Relief averaged 28% of the total from 1995 to 1999. After being substantially reduced during the middle of the period, the U.S. contribution rose to 37% in 1999. In addition to Emergency and Distress Relief, Table 7 also presents data from OECD/DAC on Development Food Aid. The average annual contribution for 1995-99 was $1,042 million. Of this, the U.S. contribution was $655 million. The U.S. has consistently furnished more than half of all developmental food aid. For the United States, this aid comprises not only PL 480 Title II, but also other items such as humanitarian assistance under Section 416 (b) of the Agricultural Act of 1949.

Another major component is peacekeeping operations. The cost of United Nations Peacekeeping Operations is available on the United Nations Peacekeeping Web page.[17] After falling to $1,300 million in 1997, this figure has risen sharply in the last few years – to $2,800 million in 2000. The U.S. contribution to this force has also risen, and is projected to be $739 million in 2001.

This does not include the substantial costs incurred in the Balkans for peacekeeping by U.S./NATO troops. During 1993-95, this cost totaled $7 billion. Although more recent data are not available, the costs are likely to have increased. The extent to which these costs can be attributed to lack of food security and low income is debatable, so they have not been included in Table 7, but clearly this has played some role.

[17] http://www.un.org/Depts/dpko/dpko/home_bottom.htm.

Table 7: Peacekeeping and Humanitarian Assistance Costs

($ million)

	1995	1996	1997	1998	1999	2000	2001	Mean (95-00)	Estimated Avg Annual Without	With	Savings
Emergency and Distress Relief											
DAC Bilateral (OECD/DAC) (a)											
Total	3062	2692	2163	2786	4365			3013.6	3000	2028	972
United States	789	585	340	898	1603			843	850	574.6	275
Global											
Complex emergencies (b)	1569	1402	838	1255	1710	1440		1369	1350		
Natural disasters (c)		84	303	1151	296	381		443	450		
Natural disasters (d)	1493	1290	1325	1531	2655			1659	1650		
Developmental Food Aid (OECD/DAC) (a)											
All DAC Countries (OECD/DAC)	1346	821	1081	919	1045			1042	1050	879.9	170
United States (OECD/DAC)	771	420	718	568	799			655	650	544.7	105
Peacekeeping											
UN Peacekeeping	3300	1600	1300	1400	1800	2800		2033	2800	1892.8	907
United States				289	295	735	739	440	750	507	243
Contibution to UN Peacekeeping (e)				211	219	605	739	345	750	507	243
Other Expenditures				78	76	130		95	150	101.4	49
Refugee Assistance											
UNHCR	974	952	785	774	912	705		850	918	620.568	297
United States			700	700	906	635		735	750	507	243
Contribution to UNHCR (f)			245	245	245	245		245	250	169	81
Other Expenditures			455	455	661	390		490	500	338	162
Total											
All DAC Countries	8682	6065	5784	6334	8783			7430	8268	5759	2509
United States		1005	1758	2455	3603			2673	3000	2133	867

Notes

(a) Emergency food aid included with development food aid up to and including 1995.

(b) OCHA estimate of total funding. Generally less than reported requirements.

(c) OCHA estimate, which excludes contributions in-kind and services not costed.

(d) Obtained by subtracting OCHA estimate for complex emergencies from OECD/DAC estimate of all DAC.

(e) Estimate for FY 2000; request for FY 2001.

(f) Actual in 2000; estimated in other years, assuming U.S. contribution remains constant.

Another cost associated with civil conflict is the cost of assistance to refugees. Refugees are one of the consequences of civil disturbance, and in many cases support for them is required for many years. The United Nations High Commission on Refugees (UNHCR) is one of the few UN agencies that depends almost solely on voluntary contributions from member governments, private companies, foundations, and individuals. From 1995 to 2000, its average annual expenditures were $850 million. Of this, the U.S. funded $245 million. In addition, the U.S. government also expended separately $490 million on refugees.

Table 7 also presents the total cost of civil conflict, both for all donors and for the United States. For all donors, this cost is equal to the sum of the following:

- Total DAC Bilateral Emergency and Distress Relief
- All DAC Countries Development Food Aid
- UN Peacekeeping
- US Other Expenditures on Peacekeeping
- UNHCR Refugee Assistance
- US Other Expenditures on Refugee Assistance

For the United States, this cost is the sum of:

- US Emergency and Distress Relief
- US Development Food Aid
- US Total Peacekeeping
- US Total Refugee Assistance

The results suggest the total magnitude of costs to the donors associated with civil conflict. These numbers are already quite high. Total estimated costs averaged $7,430 million per year for all donors and $2,637 per year for the United States. These figures may be underestimated because they do not include peacekeeping expenditures and refugee assistance for other donors beyond that which was channeled through UN agencies. However, it may also be debated as to whether development food aid should be included, as it is in the totals in Table 7, despite the fact that, as we have argued above, much of this aid is either used for humanitarian purposes or is directed towards the poor, many of whom are the victims of civil conflict. If we leave development food aid out, the totals are $6,380 million per year for all donors and $1,987 million per year for the United States.

The last column in Table 7 is an attempt to estimate what the average annual level of costs is likely to be in the near future. This is based on both the average from 1995 to 1999 and recent trends. For example, there is every evidence that peacekeeping costs are going to remain at least as high as they have been recently, and that the US is likely to contribute at least as much to these operations. Thus, we can probably expect that the cost of civil conflict to all donors is going to remain in excess of $8 billion per year and that the cost to the United States is likely to average around $3 billion per year, inclusive of development food aid.

Cost of Not Achieving the Food Summit Target

The cost to the donors of not achieving the World Food Summit target can be estimated as the cost savings that would be achieved if that target were reached. The cost savings can then be compared with the cost to the donors of achieving the target. In estimating the cost savings, we concentrate on achieving the target through increases in agricultural production, which translate via the multiplier effect into increases in income, which lessen the likelihood of civil conflict. This is not the most efficient way of meeting the food summit target. As seen above, that would involve a combination of approaches, including improvements in women's education, access to safe water and sanitation, targeted food and income transfers at the household level, lower trade taxes, increased democracy, and several other interventions that do not directly increase agricultural production and national income. However, we have no means of empirically linking these interventions to a reduction in civil conflict.

Although efforts to increase agricultural production are likely to be at least as effective in South Asia, where most of the undernourished are found, than in sub-Saharan Africa, the problem of civil conflict is proportionately greater in Africa in relation to the size of the population. Consequently, we concentrate on agricultural production as the key to increasing incomes and reducing civil conflict in SSA, assuming that this is only part of the solution to meeting the Food Summit target, but it is an important part that can be linked to a reduction in civil conflict. For this purpose, Scenario 3: Rational Distribution for achieving the Food Summit, target is used because it allocates proportionately more resources to SSA and concentrates to a greater extent than do the other scenarios on the war-torn countries. Further shifts towards SSA could be undertaken without raising costs very much. In addition, SSA is the region where per capita income is lowest and gains in income could have the biggest effect. The cost of this scenario is $80 billion over the period until 2015, of which $22.4 billion would be for Africa. This would result in a reduction in the number of undernourished by 517 million people, of which 115 million would be in Africa, most of the rest being in South Asia.

The distribution of humanitarian assistance for complex emergencies, according to UN/OCHA estimates, includes 41% for sub-Saharan Africa. This is the only element of assistance for which geographical details are consistently available. Consequently, we assume that roughly 40% of the peacekeeping and humanitarian costs listed in Table 7 apply to SSA.

There are two major ways to increase agricultural production, according to the estimates of the cost of achieving the food summit target described earlier. One is through construction of rural roads; the other is via agricultural research. The two of these serve as a proxy for other sector-level interventions. Table 8 shows the impact of these two interventions on the percentage reduction in the cost of civil conflict in sub-Saharan Africa. The data and parameters used in this table are from Annex A.

There are approximately 79,590 kilometers of rural roads in SSA today. Scenario 3 calls for construction of an additional 57,627 km, or a 72.4 % increase. According to empirical studies described in the AIRD report, the elasticity of agricultural production with respect to road density can be assumed to equal 0.09. Thus a 72.4 % increase in road density would lead to a 6.5 % increase in agricultural production. Assuming an income multiplier of 2.0, which is well within the range of estimates for Africa, this would result in an increase of per capita GDP of

8.5%.

A similar methodology applies to agricultural research, though here the scenario calls for substantially more resources to be invested by the donors. The elasticity of agricultural production with respect to agricultural research used in the model described earlier is equal to 0.09. The income multiplier remains equal to 2.

Agricultural research expenditures in SSA currently average $636 million. Scenario 3 calls for that to increase by $600 million. With an elasticity of agricultural production with respect to expenditures on agricultural research equal to 0.09, this would result in an increase in agricultural production by about 8.5%. With a multiplier of 2, the increase in GDP per capita would be 4.1%.

These changes in per capita GDP are translated into a reduction in the probability of civil conflict by assuming that the change in GDP takes place over 10 years, resulting in both an increase in the rate of growth of GDP as well as a rise in its level. The impact of this on civil conflict is taken from Auvinen and Nafziger (1999), who found that a 10% increase in GDP growth and a doubling of GDP per capita would each reduce the probability of a complex emergency by 13%. Table 8 suggests that the reduction in this probability, which would result from meeting the food summit target, would be about 81 percent. This reduction in probability is then translated into a proportional reduction in costs in Table 7. The only exception to this is for Developmental Food Aid, where the impact on costs is diminished by one-half because of the weaker link between the need for this aid and civil conflict.

The reduction in costs would be on the order of about $2.5 billion per year for all OECD donors and about $900 million for the United States -- a cost reduction that would continue indefinitely. Over ten years, for example, these benefits would total about $25 billion for all donors, compared with the cost of the Rational Scenario for meeting the Food Summit target of $80 billion. Although the value of these benefits to the donors would be somewhat less than this because of discounting, the figure of 2.5 billion per annum is also underestimated because it only applies to Africa, where the potential gains from a reduction in conflict are most evident. They would also exist in other areas of the world, which might result in benefits that could be double this figure.

Table 8: Estimation of Impact of Interventions on Cost of Civil Conflict for Sub-Saharan Africa

	Units	Nigeria	Ethiopia	Other War-Torn	Other LDC	Other Developing	Total
Rural Roads							
Rural population	million	67.5	48.8	116	81.4	81.9	
Agricultural GDP per capita	1985 $ PPP	800	255	623	545	1786	
Total agri GDP	1985 $ PPP, million	54000	12444	72268	44363	146273	329348
Agricultural share of GDP		0.32	0.50	0.20	0.50	0.20	
Total GDP		170463.7	25003	356369	88726	721306	1361868
Current rural roads	km	47104	6835	9628	4353	11670	79590
Current road density	km/km2	0.156	0.065	0.313	0.210	0.613	
% Change in rural road	km	29.77%	135.69%	233.63%	271.89%	0.00%	
Increase in rural roads		14023	9275	22494	11836	0	57627
Elasticity of agri prod/road density							0.09
Income mulitplier							2
Increase in agri GDP							57627
Increase in GDP							115254
% increase in GDP							8.5%
Annual increase in rate of growth over 10 years							0.819%
% decrease in probability of civil conflict due to							
increased rate of growth of GDP							53.2%
increased level of GDP							1.1%
Agricultural Research							
Current ag research expend		86.9	40.5	141	112.9	254.6	635.9
% change in agricultural research		129%	244%	170%	112%	9%	
Increase in agricultural research		112.2	98.9	239.9	126.3	22.9	600.2
Elasticity of agri prod/research							0.09
Income mulitplier							2
Increase in ag production							27979
Increase in GDP							55958
% increase in GDP							4.11%
Annual increase in rate of growth over 10 years							0.404%
% decrease in probability of civil conflict due to							26.2%
increased rate of growth of GDP							0.5%
increased level of GDP							
Total Decrease in Probability of Civil Conflict							81.1%

Impact of Food Security on Health Care Costs

There is significant research linking undernutrition to a decreased level of health and even death. Inadequate diet accounts for a large proportion of the world's incidence of disease, including as much as a quarter among children. Decreased height for age, or stunting, is the most common symptom of undernutrition. Approximately 40% of children in underdeveloped nations are stunted. Though less prevalent, low weight for age, or wasting, is another common consequence of undernutrition. These links continue into adulthood, where decreased height and weight lead to increased mortality (WDR, 1993, pp. 75, 77-78).

The most important component of malnutrition is protein-energy deficiency. Usually the two go together. Many health problems also result from a lack of specific nutrients. Sometimes, this is caused by a deficit in the supply of certain foods. In addition, however, many people are unaware of what a balanced diet is comprised of. Specific health problems caused by micro-nutrient deficiencies include reduced physical and mental activity from a lack of protein and iron; vision loss and blindness from a lack of vitamin A; and mental retardation, delayed motor development, and neuromuscular, speech, and hearing disorders from a lack of iodine (WDR, 1993, pp. 77-78).

The total impact of malnutrition on health is much greater than would be indicated by its direct effects because even mild or moderate nutritional deficiencies are important risk factors for illness and death resulting from disease. For example, studies indicate that mild to moderate stunting or wasting in Africa and Asia contributes "… 25 to 50 percent of childhood mortality". (WDR, 1993, p.77). In addition, although when a child is severely undernourished, the most important factor for increasing growth is to increase food intake, when a child is only slightly or moderately undernourished, controlling infectious diseases is just as important. This is because fighting these diseases requires extra calories. Intensifying the problem, some infectious diseases, including malaria, diarrhea, and parasitic worms, decrease appetite and, hence, reduce food intake. Because of these factors, a diet comprised of the same number of calories given to a healthy and unhealthy child is not equivalent (WDR, 1993, p.79).

Despite the depth of knowledge concerning the link between undernutrition and health, relatively little is known about quantitative relationships between undernutrition and the cost of health. Therefore, a cross-country statistical analysis on about 150 countries was performed to test for this relationship. Using two different approaches, the results indicate that the prevalence of undernutrition is positively correlated to public health expenditures (Annex B). Simply stated, as the prevalence of undernutrition decreases, so do public health expenditures. The correlation between malnutrition and total health expenditures, both public and private, was found to be less statistically significant. Furthermore, the prevalence of undernutrition based on infant and child anthropometric measures (WHO) was found to be more closely correlated with public health expenditures than that based on dietary energy supplies (FAO).

The first approach correlated prevalence of undernutrition directly with public health expenditures. The second, indirect, approach correlated the prevalence of undernutrition with two measures of health, and then correlated these measures with expenditures on health. The two health indicators were the rate of infant mortality and a general health index based on Disability Adjusted Life Years (DALYs), i.e., the present value of future disability-free years

lost as a result of premature death or disability occurring in a particular year (WDR 1993, p. x). Because the analysis showed infant mortality to have a more significant positive relationship with the prevalence of undernutrition than the general health index, it was used in the second correlation with health expenditures. This is supported by a 1984 Martorell and Ho study, which found that severely malnourished children have greatly increased mortality rates (Behrman and Deolalikar, 1988, p. 667).

The second step of the indirect method compares infant mortality to public health expenditures. This relationship is both significant and positively correlated. Because both the first and second step of the indirect method yield positive correlations, transitively, the results of the indirect method mirror those of the direct method. The severity, or depth, of undernutrition is also a significant additional indicator of infant mortality and of health expenditures.

Although the results vary somewhat in magnitude, depending on the particular approach used, the analysis in Annex B suggests that a one percent decline in the prevalence of undernutrition saves roughly $1 (PPP 1985 dollars) in public health expenditures for each member of the entire population. This is a very substantial saving. Its magnitude is supported by a study that showed that improved nutrition in Britain led to 30 percent of the growth in per capita income from 1790 to 1980 (Foster and Leathers, 1999, p. 54).

The value of these savings can be estimated from the decline in the prevalence of undernutrition required to meet the Food Summit target. According to the estimates in this report, which are very close to those of FAO, the number of people who are suffering from undernutrition will have to be reduced by 517 million to meet the food summit target. This is equal to 8.9% of the population of the developing countries projected for the year 2015. According to the estimates found in Annex B, this would save $8.9 per annum (each member of the population) for these countries – **or a total of $52 billion (PPP 1985 dollars) per annum.** This may be compared with the total value of public health expenditures for these countries of about $190 billion (PPP 1985 dollars). The total savings would thus be very great.

It is impossible to estimate very precisely the savings that would result to donors, but it is clear that they are increasingly being called upon to support public health in developing countries. Much attention is being focused on how the donors could contribute to improved health through the development of vaccines and other measures involving the provision of "international public goods" (WDR 2000/2001, 2001, pp.182-83). Donors not only fund public health directly in many countries, but also they provide indirect funding. The HIPC program, for example, exchanges debt relief on the part of the donors for local government commitment to spend the resulting savings on health and education. As a result, if there were substantial savings in public health expenditures generated through meeting the Food Summit target, this would make available substantial resources that would otherwise be required to deal with problems associated with the health effects of undernutrition. Certainly, these saving would amount to many billions of dollars.

Impact of Food Security on HIV/AIDS

One important area of public health for which undernutrition is an important element is HIV/AIDS. In sub-Saharan Africa (SSA), the prevalence of HIV is greater than two percent in almost all countries; it exceeds five percent in 24 countries. HIV has also been expanding rapidly in Asia during the past few years, though prevalence rates remain much lower than in Africa. In Latin America, although national rates tend to be less than one percent, the prevalence of HIV in the larger cities is equal to rates in Southern Africa a decade ago (Stillwaggon, 2000a, p. 3).

There is extensive literature on the effects of HIV/AIDS on agricultural production. FAO, for example, cites increasing evidence that HIV/AIDS, especially in Africa, intensifies labor bottlenecks, increases malnutrition, and reduces labor productivity. In addition, area cultivated declines, yields are reduced, animals are sold to buy medicines, children are withdrawn from schools, and management capacity deteriorates as younger, unprepared survivors take over the farms (FAO, 2000a; FAO, 2000b).

Much less attention has been paid to the effect of increased agricultural production and food security on the incidence and severity of HIV/AIDS. There is the common presumption that HIV results from very high rates of sexual activity with multiple partners, and efforts to combat the disease are accordingly focused on the distribution of condoms and efforts to change patterns of behavior (World Bank, 1999). Nowhere is this tendency to attribute HIV/AIDS to sexual behavior more pronounced than in Africa. "Recent empirical work, however, demonstrates the impossibility of attributing differentials in HIV transmission solely to differences in sexual behavior." (Stillwaggon, 2000b, p.2) "The AIDS literature in the social and biomedical sciences clearly demonstrates the importance of a broad array of factors in the spread of HIV, including gender relations, labor migration, malnutrition, parasitosis, and poor access to hygiene and curative care for STDs." (Stillwaggon, 2000b, p. 3)

> Epidemiological, clinical, and laboratory evidence shows that HIV infection is influenced by the same factors that promote transmission of other infectious diseases. There is an established literature in public health and a century of clinical practice demonstrating that persons with nutritional deficiencies, with parasitic diseases, whose general health is poor, who have little access to health services, or who are other wise economically disadvantaged have greater susceptibility to infectious diseases, whether they be transmitted sexually, by food, water, air, or other means. (Stillwaggon, 2000a, p. 1)

"Two factors that we find across sub-Saharan Africa that are known to undermine immune system response are malnutrition and parasite infection." (Stillwaggon, 2000a, p. 4) "On a global scale, probably the leading cause of increased host susceptibility to infection is malnutrition." (Morris and Potter, 1997). Parasitic infection produces immune system exhaustion because of chronic immune response to the presence of foreign bodies (Bentwich *et al*, 1995). Stillwaggon goes on to argue "… that biomedical evidence supports the conclusion that malnutrition and parasite infection increase HIV susceptibility, not only to opportunistic infection after HIV infection, but also to HIV transmission, just as they increase susceptibility to other infectious diseases." (Stillwaggon, 2000a, p. 5)

This does not mean that sexual behavior does not play an important role in the transmission of HIV. There is ample evidence that it does (World Bank, 1999). But, even if it is a necessary condition, this does not mean that it is sufficient. There is substantial evidence that rates of transmission per exposure to HIV are much higher for undernourished people than for those who are adequately nourished (Sanders and Sambo, 1991). So, it seems likely that both frequency of contact and susceptibility to infection are important.[18]

> In the 1970s and 1980s, when the AIDS pandemic had its origins, sub-Saharan Africa suffered worsening poverty, drought, and malnutrition. According to World Bank data, between a quarter and a half of the population of the region suffered serious malnutrition. Ninety million people consumed less than 80 percent of the FAO/WHO caloric requirement…. From 1988 to 1998, when nascent or concentrated AIDS epidemics developed into generalized epidemics in sub-Saharan Africa, 30 percent of the population of the region was malnourished. (Stillwaggon, 2000, p. 6).

Stillwaggon (2000a) estimated the quantitative impact of change in caloric intake from 1970 to 1995, change in urban population from 1970 to 1995, inequality of income distribution (measured by the Gini Coefficient), level of per capita income (PPP), and rate of growth of per capita income from 1960 and 1995 (PPP) on two measures of the prevalence of HIV/AIDS. One relates to urban low risk populations, e.g., women attending prenatal clinics, which is part of the HIV/AIDS Surveillance Data Base of the U.S. Bureau of the Census. The other comprises measurement at the national level of the prevalence of HIV in adults, as estimated by UNAIDS. All the data apply to individual countries, of which there are 44 in Asia, Africa, and Latin America with relatively complete data.

The results show a highly significant negative correlation between the prevalence of HIV according to each measure and change in the consumption of calories. Also significant is a very strong positive correlation between inequality of income distribution and prevalence of HIV. Change in urban population is also strongly and positively correlated with prevalence of HIV. The other variables are either inconsistent as between the two measures of HIV prevalence or are not at all statistically significant.

The coefficient of change in per capita calorie consumption is –28.2 for the urban low risk population and –19.0 for national HIV prevalence. We assume that this coefficient equals roughly 20, which implies that an increase in per capita calorie consumption by 100 kcal will lower the national HIV prevalence rate by 5%.

Table 9 presents data by region on the number of those suffering from undernutrition and the total calorie deficit projected for 2015 with and without the interventions described as Scenario #3: Rational Distribution in Table 5. The calorie deficits are calculated from FAO country-level estimates of calorie deficits per undernourished person multiplied times the number of undernourished persons in the late 1990s for each country. These figures were then adjusted to the year 2015 on the basis of the expected change in the number of undernourished with and

[18] The specific mechanisms by which malnutrition compromises the immune system are outlined in detail in Stillwaggon (2000a, pp. 13-18), based on an extensive survey of recent medical research on this subject.

without the interventions to achieve the food summit target. Without any intervention, it is estimated that the total calorie deficit for all developing countries will be 264 billion kcal in 2015. The interventions proposed in Table 5 to meet the food summit target would decrease the calorie deficit by 148 billion kcal, which will reduce the number of undernourished by 517 million. Divided by the total population projected to 2015, the decline in the per capita calorie deficit would equal 25.5 kcal per person. To the extent that the estimates described above are an accurate predictor of the prevalence of HIV, the reduction in this prevalence would be about 0.9 percentage points in all developing countries. It would be proportionately greater in South Asia and sub-Saharan Africa because the percentage reduction in calorie deficit would be greater there than elsewhere.[19] According to the estimates, the prevalence of HIV in these regions would decline by about 1.5 percentage points.

Table 9: Impact of Rational Distribution Interventions on Number Suffering Undernutrition and Total Calorie Deficit in 2015 (Millions)

	East & South East Asia	South Asia	SSA	Latin America	Rest of World	Total
Without Intervention						
Number Suffering Undernutrition	204	462	165	24	57	911
Total Calorie Defecit	51920	135766	54027	6125	15728	263566
With Intervention						
Number Suffering Undernutrition	95	225	50	7	19	394
Total Calorie Defecit	24125	66088	16422	1807	7064	115506
Gain with Intervention						
Number Suffering Undernutrition	-109	-237	-115	-17	-38	-517
Total Calorie Defecit	-27795	-69678	-37605	-4318	-8664	-148060
Total Population in 2015	2133	1650	886	607	538	5815
Total Calorie Per Capita Gain (kcal)	-13.0	-42.2	-42.5	-7.1	-16.1	-25.5

Source: Committee on World Food Security, "Assessment of theWorld Food Security Situation," Twenty-Sixth Session, Rome, September 18-21, 2000. Estimates of AIRD Food Security Model.

The contribution of meeting the Food Summit target to the reduction in pain and suffering from HIV/AIDS would be enormous. There would also be very considerable economic and financial gains in terms of increased productivity and income and decreased costs of health care. One estimate is that in the average country the annual treatment cost of AIDS per capita is about 2.7 times GNP per capita, which is more than enough to fund a year of primary school education for ten students (World Bank, 1999, p. 38).

[19] The data on calorie intake used in Stillwaggon's econometric analysis are taken from the *Human Development Report 1998*. These data actually describe calorie availability rather than intake. However, since the interventions proposed in this report attack the problem of undernutrition from several directions, it seems more reasonable to estimate their impact as gains in terms of calorie intake. This assumes, of course, that the impact that these gains would have on HIV/AIDS would be proportional to a similar percentage increase in calorie availability. In fact, it is likely that the percentage increase in calorie intake would have an even greater impact than a similar percentage increase in availability, so that we are probably underestimating the effect of these interventions on the prevalence of HIV.

It is difficult to estimate the savings in costs to the donors. There has been a substantial reassessment of the HIV/AIDS situation recently, with a call for substantially expanded resources to deal with this emergency. The Special Session of the United Nations General Assembly on HIV/AIDS, held in June 2001, approved a Declaration of Commitment calling for a "25 percent reduction of HIV infection among young men and women in the most affected countries by 2005." (Steinhauer, 2001) It is estimated by UNAIDS that the annual cost of struggling with HIV/AIDS will equal $9.2 billion by the year 2005. Of this, $4.8 billion will be needed for prevention and $4.4 for treatment. Although these sums are not huge by the standards of industrial country government budgets, this kind of funding is yet to be forthcoming (*Economist*, 2001).

"Currently it is estimated that some 36 million people worldwide are infected with the HIV virus, 95 percent of whom live in developing countries" (Committee on World Food Security, 2001a). Twenty-five million of those people live in Africa. The dynamics of HIV/AIDS are extremely complicated, and it is very difficult to extrapolate future prevalence rates from existing surveys based on small, unrepresentative samples (World Bank, 1999, p. 47). However, for the purpose of estimating the order of magnitude of the impact of improved food security on HIV/AIDS, we can start from the existing situation. In 2000 the number of new infections was estimated at 5.3 million annually, and the number of deaths from AIDS was about three million per annum. (United Nations General Assembly, 2001, p. 4).

Extrapolating a 2.3 percent annual growth in the number of living people with HIV/AIDS over the years until 2015, a total of about 51 million would suffer from the disease at the end of that period, the vast majority of whom would reside in the developing countries.[20] The corresponding prevalence rate in relation to the developing world's population would be about 0.9%. This is approximately the decline in prevalence that could be anticipated from meeting the Food Summit target, according to the parameters estimated by Stillwaggon. Focusing on sub-Saharan Africa, the projected number of HIV/AIDS infected people would be about 35 million, with the prevalence rate estimated at 4% continent-wide. Meeting the Food Summit target would reduce the prevalence rate to 2.5%.

The lowest current cost of treating HIV/AIDS with anti-retroviral drugs is about $350 per person annually (McNeil, 2001). For the entire developing world, the potential savings resulting from avoiding such treatment would be about $18 billion annually if AIDS were eliminated through improved food security. Even if infection were reduced by one half, the potential savings would still be $9 billion. In SSA alone, the potential savings would be $7.5-$13 billion. Additional savings could result from reduced cost of treating secondary infections associated with AIDS. The annual costs of treating one AIDS patient varies from about $200 to $10,000 within the developing world, though many sufferers receive no effective treatment at all.

In reality, it is highly likely that neither the donors nor the host country governments would be willing or able to fund all of these treatment costs. Nevertheless, this indicates the order of magnitude of the potential savings to donors and the public and private health sectors. The savings in avoided pain and grief to those who would otherwise contract the disease, and to their

[20] The recent acceleration in the spread of HIV in the developing countries is such that this is probably a substantial underestimate unless programs to control this spread are very effective.

families and friends, are inestimable.

A final caveat -- the medical profession is not yet fully agreed that the evidence supporting the link between nutritional status and rates of infection with HIV is solid enough that it can form the basis for major policy decisions. Thus, one should not reach the conclusion that other approaches to the prevention of HIV/AIDS through education, distribution of condoms, and other means should be reduced so as to concentrate more on improving food security. Reduction in the frequency of exposure to the virus may still be the most effective approach. However, it may not be the only approach, and it is important that the benefits of reduced infection associated with improved nutritional status not be ignored. In the longer run this could prove to be a very important tool in the fight against HIV/AIDS, and one that is quite cost effective.

Impact on the Demand for U.S. Agricultural Exports

There is strong evidence that increased food security in Africa would add substantially to the demand for U.S. agricultural exports (Pinstrup-Anderson, Lundberg, and Garrett, 2000). There is sometimes a fear that U.S. assistance in the agricultural sectors of developing nations will lead to the replacement of agricultural imports into these countries from the U.S. as a result of expanded domestic production in the developing countries. In reality, all the empirical evidence suggests that increased production of agricultural products in these countries results in a proportionately greater increase in GDP because of greater demand for other products on the part of participating farmers. This higher level of GDP then leads to increased demand for imports, including agricultural imports. For example, the IFPRI report cited above suggests that a $1 increase in agricultural output in SSA will lead to a $.57 increase in total imports and a $.18 increase in agricultural imports.

If we apply these parameters to the agricultural production increase required to meet the Food Summit target in Africa, this increase would be valued at $86 billion annually. This would result in an increase in GDP of about $171 billion, which would lead to a rise in the annual value of all African imports of about $97 billion, and of agricultural imports of about $31 billion. Although not all of this import expansion would be from United States exporters, the effect would be to increase total world demand for agricultural imports, which would have a favorable impact on world market prices. There would also be some increase in agricultural imports into South Asia resulting from the expansion of agricultural output there, but this would be much less that in SSA. Total imports would expand by about $19 billion and agricultural imports by about $2 billion. The effects elsewhere would be nil.

Conclusions

The overall conclusion of this study is that the benefits to be derived from meeting the World Food Summit target of reducing the number of undernourished people in the world by one-half by the year 2015 far outweigh the costs. This is true whether these benefits are defined to include cost savings to the donors or to partner country governments. It is even more true if we include the savings to those who are undernourished in terms of both financial costs and suffering.

The study estimates the costs associated with alternative approaches to reducing hunger under four different scenarios, or packages of interventions. It concludes that the total cost of reaching the target would be in the range of $72-$126 billion, with the most rational strategy costing about $80 billion. Stretched out over 13 years, this amounts to about an 11 percent increase in the annual level of Official Development Assistance.

It should be noted that this is substantially less than the figure quoted by the FAO as the investment necessary to achieve the target (FAO, 2001a). However, FAO's figure of $180 billion annually includes all private as well as public investment in production, storage, processing, and support infrastructure. Much of this investment is already being undertaken, though there is still an estimated shortfall at the production level of about 12%, or $21.6 billion per year, that needs to be covered if the target is to be met. Most of this investment would be in direct support of agricultural production and downstream activities. This differs from the approach taken in this study, which examines a wide range of interventions that could be used to achieve the target, including conflict prevention and resolution, democratization, economic policy reform, investment in agricultural research and rural infrastructure, targeted food aid, education of women, and improved access to safe water and sanitation. By attacking the problem on many fronts, it is possible to decrease substantially the costs of achieving the target.

The benefits of meeting the Food Summit target are very substantial. Those that have been measured here include decreased costs of humanitarian assistance and peacekeeping operations associated with civil conflict, lower requirements for public health expenditures, and decreased costs of treating HIV/AIDS. Each of these cost savings is estimated using empirical parameters that have been derived from at least one study in each area, based in each case on cross-country data. The broad cross-country results are complemented by substantial qualitative and quantitative evidence at the micro level concerning the relationships specified. Most important, the cross-country results all point to very large benefits resulting from improved food security to meet the Food Summit target – benefits that more than offset the costs involved.

There is widespread evidence that civil conflict is closely associated with poverty and food insecurity. Using empirically estimated parameters for this association, cost savings in Africa would be $2.5 billion per year for all donors and $0.9 for the United States. This compares with estimated current expenditures for peacekeeping and humanitarian assistance in Africa of $3.3 billion for all donors and $1.2 billion for the United States (assuming that 40% of total expenditures go for Africa, as discussed above). Thus improving food security in line with meeting the Food Summit target would reduce peacekeeping and humanitarian assistance costs in Africa by about 80%. Furthermore, although these benefits would accrue gradually over a period of ten years, they would continue to persist after the cost of improving roads and undertaking research have been incurred.

The impact of improved nutrition on public health expenditures is shown to be even more important. Meeting the Food Summit target, according to the estimates reported earlier, would save $8.9 per annum (each member of the population) for these countries – or a total of $52 billion (PPP 1985 dollars) per annum, compared with the total value of public health expenditures for these countries of about $190 billion (PPP 1985 dollars). Given current pressures for donors to contribute substantially to improvements in public health in these

countries, the saving to the donors are likely to be very considerable.

In addition to these overall savings, there would also likely be a very considerable impact on the prevalence of HIV/AIDS, especially in Africa. According to the empirical evidence that is available, for every 100 kcal of additional food consumption per person, the prevalence of HIV would decrease by about 5 percentage points. Given the increase in agricultural production in Africa necessary to meet the Food Summit target, the decline in the prevalence of HIV could be about 1.5 percentage points on average. Elsewhere it would be much less, but overall there might be potential savings in excess of $18 billion annually to the extent that the need for treatment of HIV/AIDS was otherwise to be met. There would of course be many other benefits to those suffering from AIDS and their families, which have not been included in this analysis.

Finally, the increase in agricultural production required to meet the Food Summit target would generate annually about $116 billion in additional demand for all imports and $33 in additional demand for agricultural imports. Although not all of these imports would come from the U.S., the impact on the world market would be appreciable.

Not all the benefits from meeting the Food Summit target have of course been estimated. Aside from the relief of pain and suffering for the hungry and the sick, there are also likely to be substantial gains in terms of increased worker productivity and improved educational attainment. These have not been estimated here because most of the evidence is at the micro level and is not based on broad samples, but it is nonetheless very substantial.[21] Should these gains be added, the benefits would total many billions of dollars. Even in their absence, the quantitative benefits appear to far outweigh the costs.

[21] For a review of much of this evidence, see Strauss and Thomas (1998).

REFERENCES

Antoine, Pierre and Francis C. Byrnes (1993), "Winrock's On-farm Productivity Enhancement Program (OFPEP): Experience and Lessons Learned in West Africa," Presented at workshop on "Developing African Agriculture: New Initiatives for Institutional Co-operations," Cotonou, Benin, July 28-30.

Auvinen, Juha and E. Wayne Nafziger (1999), "The Sources of Humanitarian Emergencies," *Journal of Conflict Resolution*: 4(3), June.

Auvinen, Juha and E. Wayne Nafziger (2000), "The Economic Causes of Humanitarian Emergencies," in E. Wayne Nafziger, Frances Stewart, and Raimo Vayrynen, eds., *War, Hunger, and Displacement: The Origins of Humanitarian Emergencies*, Oxford University Press, pp. 92-145.

Barrett, Christopher B. (1998), "Food Security and Food Assistance Programs," chapter prepared for *Handbook of Agricultural Economics*, Gardner and Rausser (eds.).

Barrett, Christopher B. and Daniel C. Clay (2001), "How Accurate is Food-for-Work Self-Targeting in the Presence of Imperfect Factor Markets: Evidence from Ethiopia," http://www.cals.cornell.edu/dept/arme/staff/cbb2/FFW.pdf.

Barrett, Christopher B., Thomas Reardon, and Patrick Webb (2001), "Non-Farm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics, and Policy Implementation," *Food Policy*: 26(5), September.

Bentwich, Z., A. Kalincovicj, and Z. Weisman (1995), "Immune Activation is a Dominant Factor in the Pathogenesis of African AIDS," *Immunology Today*, 16. Pp. 187-91.

Bereman, Jere R. and Anil B. Deolalikar (1988), "Heath and Nutrition," in Hollis Chenery and T.N. Srinivasan, (eds.), *Handbook of Development Economics*, Amsterdam, North Holland, Vol.1.

Block, Steven and C. Peter Timmer (1994), "Agriculture and Economic Growth: Conceptual Issues and the Kenyan Experience," *CAER Discussion Paper No. 26*, Harvard Institute of International Development.

Bread for the World Institute (2001), "Foreign Aid to End Hunger," *Annual Report on the State of World Hunger 2001*.

Bread for the World Institute (1998), "Hunger in a Global Economy," *Annual Report on the State of World Hunger 1998*.

Chan-Kang, Connie, Philip G. Pardey, Stanley Wood, Johannes Roseboom, and Marleen Cremers (1999), "Reassessing Productivity Growth in African Agriculture," selected *paper for*

the annual meeting of the American Agricultural Economics Association, Nashville, Tennessee, August 8-11.

Collier, Paul and Anke Hoeffler (1998), "On Economic Causes of War," *Oxford Economic Papers* (50), pp. 563-73.

Committee on World Food Security (2000), "Assessment of the World Food Security Situation," Twenty-Sixth Session, Rome: 18 September – 21 September 2001.

Committee on World Food Security (2001a), "The Impact of HIV/AIDS on Food Security," Twenty-Seventh Session, Rome: 28 May- 1 June 2001.

Committee on World Food Security (2001b), "Mobilizing Resources to Fight Hunger," Twenty-Seventh Session, Rome: 28 May- 1 June 2001.

Cornia, Giovanni Andrea, Richard Jolly, and Frances Stewart, eds. (1987), *Adjustment with a Human face: Protecting the Vulnerable and Promoting Growth*, Oxford: Clarendon.

Craig, Barbara J., Phillip Pardey and Johannes Roseboom (1997), "International Productivity Patterns: Accounting for Input Quality Infrastructure and Research," *American Journal of Agricultural Economics*, Vol. 79, #44.

De Soysa, Indra and Nils Peter Gleditsch (1999), *To Cultivate Peace -- Agriculture in a World of Conflict,* Oslo: International Peace Research Institute.

Diamond, Jared (1998), *Guns, Germs, and Steel*, New York: Norton.

Edwards, Sebastian (1993), "Openness, Trade Liberalization and Growth in Developing Countries," in *Journal of Economic Literature*, vol. 31, pages 1358-1393.

Elbadowi, Ibrahim and Nicholas Sambanis (2000), "Why are there so Many Civil Wars in Africa? Understanding and Preventing Violent Conflict," *Journal of African Economies*, December.

Economist (2001), "Counting the Cost of AIDS", June 28.

ERS/USDA (1997), International Agricultural Baseline Projections to 2005, May.

FAO (2000d), "AIDS and Agriculture in Africa: Can Agricultural Policy Make a Difference?," www.fao.org/docrep/X4390e/X4390e302.

FAO (2001b), "Food insecurity and AIDS: A vicious circle," http://www.fao.org/Focus/E/aids/aids2-e.htm.

FAO (2000a), "HIV/AIDS and Agriculture: an FAO Perspective," SD Dimension, www.fao.org/WAICENT/FAOINFO/SUSTDEV/Wpdirect/Wpre0129.htm, April.

FAO (1999), "HIV/AIDS and the commercial agricultural sector in Kenya: Impact, vulnerability, susceptibility and coping strategies," SD Dimensions, www.fao.org/sd/Exdirect/Exre0026.htm, July.

FAO (2000b), "Impact du VIH/SIDA sur les Systèmes d'Exploitation Agricoles en Afrique de l'Ouest," www.undp.org/popin/fao/impact/impactfi.htm.

FAO (2001a), "Mobilizing Resources to Fight Hunger," CFS: 2001/INF.7, prepared for the 27th meetings of the Committee on Food Security, May 28 - June 1.

FAO (1996), *The Sixth World Food Survey*, Rome.

Foster, Phillips and Howard D. Leathers (1999), *The World Food Problem: Tackling the Causes of Undernutrition in the Third World*, Boulder: Lynne Rienner.

Freedom House (2001), *Freedom in the World*, available at www.freedomhouse.org.

Haddad, Lawrence, John Hoddinott and Harold Alderman (1997), *Intra-household Resource Allocation in Developing Countries: Models, Methods, and Policy*, IFPRI: The Johns Hopkins University Press.

Hazell, Peter and Shenggen Fan (1998), "Balancing Regional Development Priorities to Achieve Sustainable and Equitable Agricultural Growth," Prepared for the *AAEA International Conference on Agriculture Intensification, Economic Development and the Environment*, July 31-August 1.

King, Elizabeth and M. Anne Hill (1993), *Women's Education in Developing Countries: Barriers, Benefits and Policies*, The World Bank, Washington D.C.

McNeil, Donald G., Jr. (2001), "U.S. at Odds with Europe over Rules on World Drug Pricing," *New York Times*, July 20.

Messer, Ellen, Marc Cohen, and Jashinta D'Costa (1998), "Food from Peace: Breaking the Links between Conflict and Hunger, 2020 Vision," *Food, Agriculture, and the Environment*, Discussion Paper 24, IFPRI.

Morris, J. Glenn Jr. and Morris Potter (1997), "Emergence of New Pathogens as a Function of Changes in Host Susceptibility," *Emerging Infectious Diseases*, 3(4), www.cdc.gov/ncidod/eid/vol4no3/nchinda.htm.

OECD (1998), *Conflict, Peace and Development Co-operation on the Threshold of the 21st Century*, Development Assistance Committee, Development Cooperation Guidelines Series, Paris.

Pinstrup-Andersen, Per, Mattias Lundberg, and James Garrett (1995), *Foreign Assistance to*

Agriculture: A Win-Win Proposition, International Food Policy Research Institute, Washington: June.

Pitt, Mark (1995), "Women's Schooling, the Selectivity of Fertility, and Child Mortality in Sub-Saharan Africa," *Living Standards Measurement Study, Working Paper No. 119*, The World Bank, Washington D.C.

Renner, Michael (1996), *Fighting for Survival - Environmental Decline, Social Conflict, and the New Age of Insecurity*, New York: Norton.

Rodgers, Beatrice Lorge and Nina P. Schlossman (1990), *Intra-Household Resource Allocation: Issues and Methods for Development Policy and Planning*, United Nations University Press.

Rosegrant, Mark W., M. Agcaoili-Sombilla and N.D. Perez (1995), "Global Food Projections for 2020: Implications for Investment," *Food, Agriculture and the Environment Discussion Paper, No. 5*, IFPRI, Washington D.C., October.

Rosegrant, Mark W., Nancy Leach, and Roberta V. Gerpacio (1998), "Alternative Futures for World Cereal and Meat Consumption," IFPRI, Washington D.C., July.

Sachs, Jeffrey D. and Andrew M. Warner (1996), "Sources of Slow Growth in African Economies," *HIID Development Discussion Paper No. 545.*

Sachs, Jeffrey D. and Andrew M. Warner (1995), "Trade Openness Indicators," www.cid. harvard.edu/ciddata/ciddata.html.

Sanders, David and Abdulrahman Sambo (1991), "AIDS in Africa: the Implications of Economic Recession and Structural Adjustment," *Health Policy and Planning*, 6(2), pp. 157-165.

Schnepf, D. Randall (1992), "Nutritional Status of Rwandan Households: Survey Evidence on the Role of Household Consumption Behavior," *Working Paper 23*, Cornell Food and Nutrition Policy Program.

Schnepf, D. Randall (1991), "Understanding the Health and Nutritional Status of the Children in Rwanda," *Monograph 13*, Cornell Food and Nutrition Policy Program.

Smith, Lisa and Lawrence Haddad (1998), "Explaining Child Nutrition in Developing Countries: A Cross-Country Analysis," IFPRI, Washington D.C., Draft, April.

Sollenberg, Margareta, and Peter Wallensteen (2000), "Armed Conflict, 1989-99,"

Journal of Peace Research: 37 (5), pp. 635-649.

Spencer, Dunstan (1994), "Infrastructure and Technology Constraints to Agricultural Development in the Humid and Subhumid Tropics of Africa," *IFPRI/EPTD Discussion paper #3*, August.

Steinhauer, Jennifer (2001), "U.N. Redefines AIDS as Issue of Rights and Peril to the Poor," *New York Times*, June 28.

Stillwaggon, Eileen (2000a), "HIV/AIDS in Africa: Fertile Terrain," February 20.

Stillwaggon, Eileen (2000b), "Determinants of HIV Transmission in Africa and Latin America," August 18.

Strauss, John and Duncan Thomas (1998), "Health, Nutrition, and Economic Development," *Journal of Economic Literature*: 36, June, pp. 766-817.

Strauss, J. and D. Thomas (1997), "Human Resources: Empirical Modeling of Household and Family Decisions," *Handbook of Development Economics, Vol. 3.A,* Amsterdam: North Holland, pp. 1894-1895.

Stryker, Dirck and Jeffrey C. Metzel (1998), "Meeting the Food Summit Target--The United States Contribution: Global Strategy," *APAP III Research Report No. 1039,* Abt Associates, September.

Stryker, J. Dirck and Selina Pandolfi (1997), "Impact of Outward-Looking, Market-Oriented Policy Reform on Economic Growth and Poverty," *CAER II, Discussion Paper #7*, June.

Summers, Lawrence H. (1994), "Investing in All the People: Educating Women in Developing Countries," *World Bank/EDI Paper number 45*.

Timmer, C. Peter (1997), "How Well do the Poor Connect to the Growth Process?," *CAER II Discussion Paper No. 17,* Harvard Institute of International Development.

UN/AIDS (2001), www.unaids.org.

United Nations General Assembly (2001), Special Session of the General Assembly on HIV/AIDS, Report of the Secretary-General, February 16, 2001.

U.S. Action Plan on Food Security (1999), prepared by the Interagency Working Group on Food Security and the Food Security Advisory Committee, Washington: U.S. Government Printing Office, March.

Väyrynen, Raimo (2000), "Complex Humanitarian Emergencies: Concepts and Issues," *War, Hunger and Displacement, The Origins of Humanitarian Emergencies*: Vol. 1, Oxford: Oxford University Press, pp. 43-89.

World Bank (1999), *Confronting AIDS: Public Priorities in a Global Epidemic*, Oxford: Oxford University Press.

World Development Indicators (2000), World Bank, Washington, D.C.

World Development Report 1993 (WDR 1993) (1993), World Bank, Washington, D.C.

World Development Report 2000/2001(WDR 2000/2001) (2001), World Bank, Washington, D.C.

The World Health Report 1999, World Health Organization.

ANNEX A
Food Security Model Description and Tables

The Food Security model seeks to evaluate, for a set of specific interventions, the impact of each intervention on the projected population in a state of undernutrition in the year 2015.[22] The model has been developed to examine the relative impact of different interventions in different countries and regions of the world. This analysis is part of an exercise to develop a global strategy for meeting the 1996 World Food Summit target of reducing the number of chronically undernourished in the world to 400 million by the year 2015.

In order to estimate the cost of achieving the Food Summit target of reducing the number of undernourished to 400 million by the year 2015, empirically derived parameters were used to link the interventions discussed above to resulting declines in undernutrition. A number of scenarios were then costed out using different combinations of these interventions to achieve the Food Summit target. It was assumed that these interventions are incrementally added to the baseline interventions assumed in the projections discussed earlier and that they are for the most part financed by the donors. The countries and sub-regions for which these calculations were made are China, Indonesia, Rest of East and Southeast Asia, Pakistan, India, Bangladesh, Rest of South Asia, Nigeria, Ethiopia, War-Torn sub-Saharan Africa (minus Ethiopia), Least Developed SSA, Developing SSA (minus Nigeria), Latin America and the Caribbean, and Rest of the Developing World.[23] Because of higher levels of per capita income and lower levels of undernutrition in Latin America and the Caribbean, and in the Rest of the World, it was assumed that interventions in these regions would be financed by the countries themselves rather than by the donors. These costs from own resources do not appear in the totals. The sole exception to this is technical assistance for policy change, which was assumed to be financed by the donors.

Because of severe time and resource constraints, both in 1998 and for this updating, the model's principal objective is to be accurate in comparisons of "relative" impacts in order to provide guidance in prioritizing interventions. Absolute numbers are much less meaningful and should only be interpreted as providing an "order of magnitude" of actual values. Limitations and weaknesses of the model are discussed further below.

[22] By state of "undernutrition", we mean that the individual does not absorb sufficient calories into his or her body, whether because of lack of availability, access, or utilization of the calories. According to FAO, this is not quite the same as saying the individual is "undernourished", which is associated only with lack of availability and/or access.

[23] The regional groupings include country-level data on the "input" side of the model, that is to say, up to the "base case" projections of the situation in 2015 without additional intervention.

Measuring the Level of Undernutrition

The AIRD Food Security Model's assessment of the total level of *undernutrition* relies on anthropometric estimates of the proportion of children 0-5 years who are underweight in each country. These data are assembled in the WHO global database on child growth and are also reported by FAO in the Sixth World Food Survey (1996).[24]

Projections of the numbers in a state of undernutrition in the AIRD Food Security Model are distinct from but incorporate many of the elements of IFPRI's global food model entitled IMPACT (International Model for Policy Analysis of Agricultural Commodities and Trade). The IMPACT model, reported in Rosegrant, Leach, and Gerpacio (1998), relies on the following variables to project child malnutrition.

- per capita kilocalorie availability,
- percent of social expenditures as a share of total expenditures,
- percent of females with secondary education,
- percent of households with access to clean water, and
- a dummy variable for South Asia.

The IFPRI projections of child malnutrition to the year 2015 rely on changes in each of these variables. The projection of changes in kilocalorie availability is evaluated directly by IFPRI's IMPACT model. IMPACT includes 18 commodities (all major cereals, soybeans, roots and tubers, meats and dairy products) and covers 37 countries and regions. Each country or region is defined by a series of supply and demand equations and is linked to the rest of the world through trade. Crop prices and projected rates of productivity growth determine food supply growth in each country. Food demand is a function of food prices, income and population growth. Details of the basic methodology of the model are described in Rosegrant et al (1995). For countries not included in the IFPRI model, the AIRD food security model relies on projections by the FAO of food availability to the year 2015. All told, there is country-level detail for 99 countries, aggregating up to the 14 countries or regions for the output projections.

For other variables of the IFPRI/IMPACT child undernutrition model, projected changes to 2015 were unavailable. Therefore, assumptions were made reflecting a continuation of trends in each variable between 1970 and 1990. Table A.1 shows the assumed cumulative change by the year 2015.

[24] The text of the FAO's *Sixth World Food Survey* discusses the relative merits of this anthropometric measure for undernutrition.

Table A.1: Assumed Increases in Underlying Variables between 1995 and 2015

	Food availability (DES)	Access to safe water (%)	Female secondary enrollment rate (%)
East and Southeast Asia		18%	41%
South Asia		15%	82%
Sub-Saharan Africa		27%	49%
Latin America + Caribbean		5%	19%
Rest of world		15%	25%

The extrapolator to the number of those in a state of undernutrition in the total population from the projected number of malnourished children assumes that the percent in undernutrition in the larger population is proportionate to the percent of children under 5 who are malnourished. However, the proportion used is not a one-to-one ratio, but rather assumes that the rate of undernutrition of people over 5 years old is 50% of the child malnutrition rate. This proportion is used for two reasons. First, a comparison of the percentage of underweight adults to the percentage of underweight children -- in a small sample of surveys for which both are available - suggests that the mean ratio of adult to child rates of undernutrition is roughly 50%. Presumably this is at least in part because of higher mortality among those in a state of undernutrition. It is also because of the greater ability of adults, especially males, to have adequate food intake. This empirical evidence, however, is admittedly very weak, both because the sample of countries is small (6 surveys), and because the variability in the ratio observed is quite large across these countries.[25] Secondly, using this measure, the total number of those in *undernutrition* in 1995 (915 billion) is roughly equivalent to the FAO number of total *undernourished* in 1990-92 (840 billion). This similarity is expedient, even if not entirely accurate, because it allows us to argue that, using this measure, we are addressing the same magnitude of problem in 1995 that the FAO identified in the World Food Summit of 1996. As the discussion in the text points out, however, the regional distribution of these numbers is substantially different, with South Asia showing much greater numbers in a state of undernutrition according to anthropometric measures than according to FAO's measures, while sub-Saharan Africa shows fewer in a state of undernutrition when anthropometric measures are used.

Assessing the Impacts of Interventions

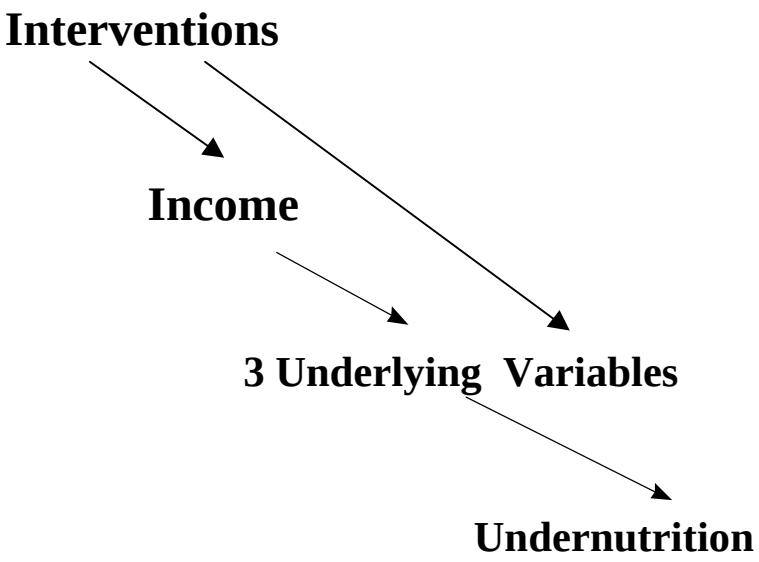
For each intervention evaluated, the AIRD Food Security Model analyzes the impact of a change in the proposed intervention on undernutrition.[26] As denoted in Figure A.1, the change in the

[25] In reviewing the work of WHO, FAO, UNDP, IFPRI, and the U.S. Department of Health and Human Services in early 2001, it is apparent that no further progress has been made toward understanding this relationship between child and adult undernutrition in the three years since the original APAP III report in 1998.

[26] The AIRD Food Security Model builds onto the country coverage in the IFPRI model, but extrapolates to the total number of people in the world who are in a state of undernutrition. It also permits estimation of the cost of different packages of interventions.

intervention may affect nutrition in several different ways. First, it may impact directly one of the underlying variables influencing nutrition, such as food availability. Second, it may influence income, which in turn affects one or more of the underlying variable. Based on Smith and Haddad (2000), these effects are converted into reductions in child malnutrition and are then extrapolated to the population as a whole. Finally, the cost of each intervention is assessed based upon unit cost data for quantifiable interventions

Figure A.1: Theoretical Construct of the Model



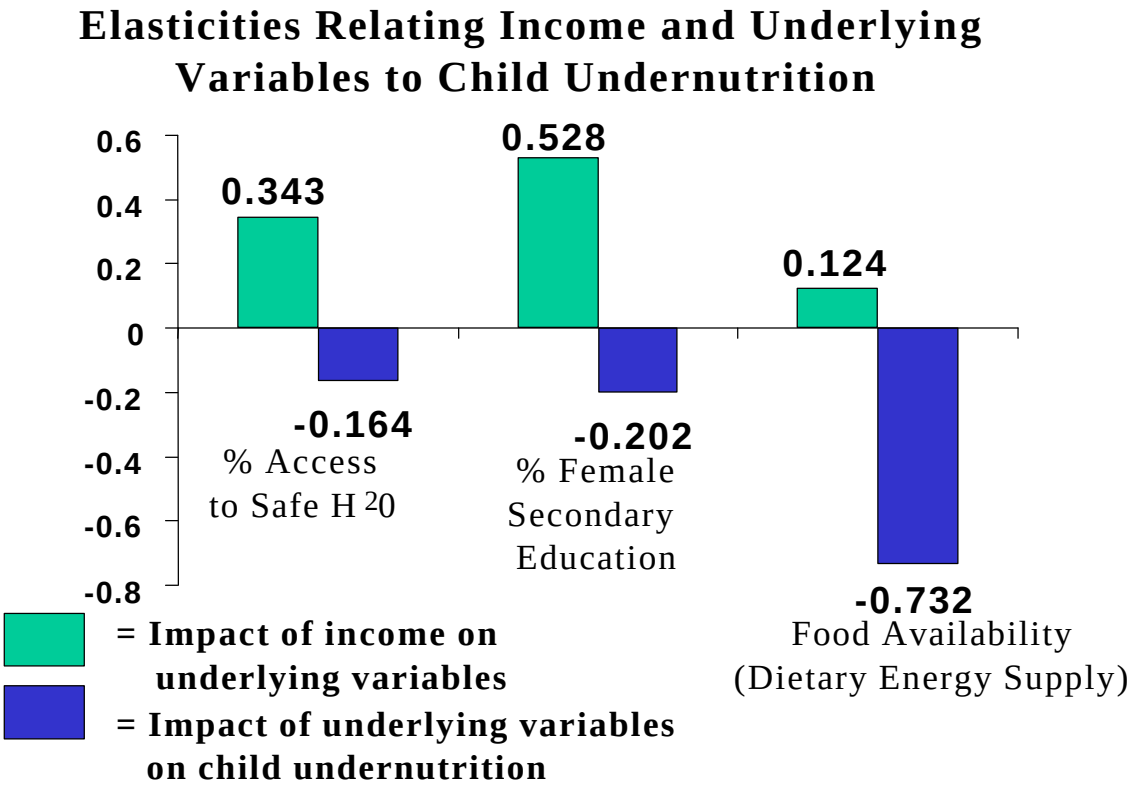
The analysis of each intervention is conducted independently of all other interventions. This implies that the model is not capturing complementary aspects among the interventions. For example, improvements in rural roads are not assumed to increase the efficacy of agricultural research. The model also ignores any preconditions that may exist with regard to some interventions. For example, open trade policy is likely to be an important factor in determining the extent of income effects generated by sectoral investments such as agricultural research or investment in rural infrastructure. These preconditions are picked up to some extent, however, in the various scenarios of interventions derived from the model.

A second set of assumptions concerns the temporal element of the model. In each case, the analysis seeks to estimate the percent change in the number in a state of undernutrition in the target year (2015). The model does not develop growth paths of each impact over the interval between the introduction of the intervention and the target year. Thus, while the intervention may occur progressively over the 13-year interval between the introduction of the intervention in 2002 and the target date of 2015, the only measure of impact is in 2015. Moreover, the ultimate impact is calculated as a reduction in the projected number of people in a state of undernutrition in that year in each region or country evaluated. There is no link made between the reduction in undernutrition that occurs because of the intervention and the effects that this might have on demographic projections, which could influence the base level of undernutrition in the target year. A related assumption is that regardless of when in the interval until 2015 each intervention

occurs, it is assumed to have lasting effects on the number of those in a state of undernutrition through the target date and into the future. As such, each intervention's effects are assumed to be "permanent" over the horizon of the analysis.

To establish links to undernutrition, all impacts (except those related to Political Stability and Targeted Food Aid interventions) are traced through various "pathways" to three underlying variables, which Smith and Haddad (2000) have found to be most influential in explaining child undernutrition. These underlying factors -- food availability, female secondary education[27], and access to safe water -- were found to be causally related to the prevalence of child underweight. Figure A.2 shows the sign and magnitude of the elasticities relating income to the underlying variables and linking the underlying variables to child undernutrition. Most of the national and sector interventions operate primarily through changes in income, whereas household and intra-

Figure A.2: Technical Parameters for the Three Key Variables



household interventions tend to operate more directly on the underlying variables. Table A.2 below provides the multipliers and elasticities for each of these relationships.

[27] In this AIRD analysis, a related variable, the effect of improvement in women's status, is added to the secondary education effect based on Smith and Haddad (2000).

Table A.2: Parameters Relating Underlying Variables To Child Undernutrition

	Impact of Income on Underlying variables		Impact of Underlying Variables on Child Undernutrition (%)	
Underlying variables	Parameter	Elasticity	Parameter	Elasticity
% Access to Safe Water[a]	0.000092	0.343	-0.072	-0.174
% Female Secondary Education[a]	0.000083	0.528	-2.32	-0.302
Food Availability (DES)	0.1414	0.124	-0.67	-0.949

Source: Smith and Haddad (2000).

[a] These parameters are expressed by Smith and Haddad as percentage points. In the Food Security Model, these are expressed as fractions and therefore each parameter is reduced by a factor of 100.

The impact of each intervention on the broader population suffering undernutrition is extrapolated from the impact on child undernutrition. As with the relationship between the prevalence of undernutrition between the two groups, no literature could be found which describes the differential impact of the nutrition interventions on the two cohorts. The model therefore makes the following assumptions. First, it assumes a one-to-one relationship between the impact of each intervention on older children (between the ages of 5 and 15 years old) and the measured impact for children 0 through 4 years old. This relationship is assumed because children affected by interventions at the beginning of the intervention period will nearly all be 15 years old by the end. Interventions are therefore assumed to have had the same impact on each of the two age cohorts of children.

With respect to the adult population, interventions are assumed to have a similar effect on adults as on children. This assumption is the subject of considerable discussion, due to the different character of undernutrition in the adult population. A large component of underweight adults are underweight because of stunting at an early age (nearly all stunting occurs before the age of five). Stunting in adults is not remediable and therefore interventions to reduce undernutrition will not have as much impact on adults as on children. Nevertheless, the spirit of the Food Summit target seems to be to ignore this problem and to try to achieve the conditions by the year 2015 that would over the longer run result in a halving of the degree of undernutrition. This issue is discussed in greater detail in Box One.

Box One

NOTE ON ASSUMPTIONS REGARDING RATIO OF IMPROVEMENT IN CHILD MALNUTRITION RELATIVE TO THAT OF ADULTS

Our analysis assumes that interventions have an impact on the nutritional status of adults that is similar in strength to the effect on children. This cannot occur over the shorter run since only wasting, not stunting, in adults can be remedied, and wasting accounts for only about one-quarter of all undernutrition.

One line of reasoning is that the nutritional intake requirement is less for the population that is permanently stunted. Thus FAO, in defining norms for adequate intake, ignores the fact that the requirement for existing adults is less than it would be for those adults if they had achieved their genetic potential. In a sense, FAO is defining nutritional adequacy in terms of long-run, not short-run, needs – thus overestimating requirements to achieve the target.

One alternative might be to target resources carefully so as to eliminate wasting throughout the population and reduce stunting seriously in the age cohort 0-4. If we focused our resources on those who are age 0-4, we would reduce stunting to the maximum extent possible within a 15 year period. Within the 5-15 group, we would be more effective, as with adults, by concentrating on wasting rather than stunting. However, because wasting is less important than stunting, and because stunting cannot be reduced beyond the age 0-4 cohort, it would be very difficult to meet the Food Summit target if this target is only defined over the shorter run as applying to those actually alive in 2015.

Thus we share what we believe to be the spirit of the Food Summit target and concentrate on establishing the conditions by 2015 that will be necessary to cut undernutrition in half over the longer term as children grow to be adults.

National Level Interventions

At the national level, four policy-based interventions have been examined. These address political stability, democratization, openness and trade tariff reform. In addition to the direct and/or indirect effects that each has on undernutrition, all are also considered to be necessary components of a policy environment conducive to interventions which are more closely linked to combating undernutrition. In the absence of these reforms, interventions at the sectoral level are not likely to be worthwhile, although some interventions at the household and intra-household level may still be feasible.

Before turning to the details of each of these interventions, it should be noted that because each is of a policy nature, the costs are difficult to quantify. At the end of this section, an approach to this problem is proposed, but for all interventions rather than for each intervention individually.

Intervention 1: Political Stability

Logic: The well known direct negative effects of civil war and strife on physical security are assumed to reduce people's ability to access food. In addition, food production, and therefore food availability, is disrupted. Furthermore, during periods of war, the general level of public services is curtailed both because of difficulty in accessing and the general shortages of funds to render services. Finally, income reductions and asset losses due to war reduce people's entitlement to food.

Data and Assumptions: The intervention analysis examines the impact of establishing peace before 2015 in each region or country where war and civil strife have been present in the last ten years. To assess this effect, a cross-country OLS regression was used to evaluate child undernutrition levels between 1990-92 as a function of the country having been a war-torn country in the last ten years, as well as a function of other underlying variables associated with child undernutrition. The results consistently show a highly significant increase of about 8 percentage points in the level of undernutrition of children, holding other underlying variables constant (region, female education, access to safe water, female status), due to the presence of war.[28]

Obviously, the costs of achieving peace in these countries are difficult to assess. However, the scale of interventions is not necessarily high if proactive measures to avert conflict can be taken. Budgets sufficient to engage conflicting parties in sustained dialogue are included. This dialogue would rely on techniques for conflict avoidance and conflict resolution. These efforts would necessarily be coupled with a heightened and concentrated effort by the world community to apply sustained pressure on opponents to use these procedures to resolve their differences. The process of estimating costs involved in this process is examined at the end of this section.

Intervention 2: Democratization

Logic: The effect of democratization on reducing undernutrition is traced through its impact on creating a more equitable allocation of public resources to segments of the population where those in a state of undernutrition are concentrated. The model relies on measurement of this effect by Smith and Haddad (2000). Specifically, they measure a direct link between the degree of democratization and the allocation of public resources for providing access to safe drinking water. Safe drinking water, in turn, directly affects the health of individuals and therefore their capacity to absorb nutrients. This link is discussed further under Intervention 8 below.

Data and Assumptions: Measurement of the current status of democratization uses the arithmetic average of two measures of rights that are typically attributed to democracies. These measures, calculated by Freedom House, are scores of civil liberties and political rights, ranging from 1.0 ("Free") to 7.0 ("Not Free") as calculated by Freedom House. The assumption in the analysis is that this "Comparative Measure of Freedom" improves over the interval between 1995 and 2015 by 30% of the gap between the level in 1995 and the optimum level, which is 1.0. This

[28] Regression results for the impact of war on undernutrition in children are presented in Annex Table A-7 based on the categorization of countries as "war-torn" or "peaceful." Parameters for regions were weighted according to population.

assumption reflects a rate of change of that is roughly equivalent to the historical rate of improvement in the index over the past twenty years.

This change is related to access to safe water using Smith and Haddad's finding that a 1-point gain in the democracy index increases water access by 3.49%. Access to safe water is then related to child undernutrition through the parameter reported in Table A.2.

This approach is likely to underestimate the impact of democratization on undernutrition to the extent that democratization also improves access and raises the quality of other public services to those suffering undernutrition as well. These may include such things as health care services, education, and transportation and telecommunications infrastructure.

Intervention 3: Economic Openness

Logic: The impact of open policies on the volume of trade and on economic growth is now well established.[29] Openness has both a direct impact on GDP growth and indirect effects through its stimulus on trade and investment, each of which also impacts income growth. These combined effects are assumed to have an annual compounding effect on per capita income growth for the period in which openness is sustained. Income growth, in turn, is assumed to have impacts on the three underlying variables affecting child undernutrition – food availability, female secondary education, and access to water – as indicated in Table A.2 above.

Data and assumptions: The definition of economic openness uses a variable developed by Sachs and Warner (1995). This variable classifies countries as open according to cut-off levels of the black market exchange rate premium, the influence of export marketing boards, the level of coverage of quotas on imports of intermediate and capital goods, and the absence of a socialist government. A country is considered open when all four conditions are met in a given year; otherwise the variable equals zero.

The direct relationship of trade openness to income growth and the indirect relationship to income via its impact on investment have been measured by Stryker and Pandolfi (2001). These combined effects are estimated by Sachs and Warner (1996) to add on the order of 2% to growth rates for developing countries. This parameter is therefore assumed in the analysis.

The openness status of countries or regions in 1995 is assumed to be the base condition from which changes can be obtained. In the analysis, it is assumed that open status can be achieved by the year 2005 for countries that are not open, and that this status can be maintained through the target year. For regional groupings covering more than one country, the openness parameter represents a population-weighted average of the openness parameter.

As noted above, the impact of these effects on income growth are compounded annually for successive years of openness (10 years). The original AIRD report for APAPIII presents the levels of openness, their impact on income growth, and the compounded effect on per capita

[29] Cf.: review of literature by Sebastian Edwards (1993), as well as more recent research by Stryker and Pandolfi (1997) and Sachs and Warner (1996).

income levels at the end of the projection period for each country and sub-region (Stryker and Metzel, 1998).

Intervention 4: Food Tariff Reductions

In addition to these income effects, a related effect of the impact of trade openness is traced through the effect of reduced trade restrictions on the cost of food. This applies in particular to policy reforms that remove quantitative restrictions and lower tariff barriers to food imports. The justification of this impact is that for countries which currently tax or otherwise restrict food staple imports, a reduction in the level of protection of these imports will reduce the domestic price of food staples by roughly the same percent. The percentage price change for staples is translated into a change in food caloric availability using a long-run price elasticity of demand for calories. The impact of food calorie availability on the number suffering undernutrition is traced through its relationship to child undernutrition using the equations provided by Smith and Haddad (200), and then to total numbers suffering from undernutrition (see above).

With regard to the impact of price changes induced by changes in trade policy, base levels of import protection were estimated from producer prices taken from the World Bank Development Indicators and world prices in 1993.[30] Both world prices and local producer prices were adjusted to a common urban wholesale point, inclusive of intermediate processing margins. Rates of protection were also adjusted by deflating by the ratio of the nominal to the real economic exchange rates. These show that, with the exception of South Asia, all countries/sub-regions had net nominal protection coefficients substantially in excess of one. The assumption in the analysis is that these are brought down to a target level of 1.0 by the year 2015.

To evaluate the impact on caloric availability, a long-run price elasticity of demand for calories of -0.2 was used for all countries and sub-regions. This estimate derives from similar estimates used in a variety of sources.[31]

Costs of National Level Policy Interventions

The costs entailed in achieving political stability, democratization, and trade openness are challenging to quantify since most of the difficulty in effecting these reforms is not the direct cost but rather costs arising from the political and economic repercussions on diverse interests within society. As these interventions are policy decisions, the marginal costs of each intervention are arguably close to zero, since costs inherent in the operation of the policy apparatus in each country are likely to be incurred anyway, whether or not the correct policies are introduced.[32] On the other hand, it may be argued that the choice of suitable policies will require training of the policy makers and civil society in order for them to understand the logic and requirements of sustaining openness. Costs for training and technical assistance have been roughly estimated from past technical assistance contracts focused on reform of national trade

[30] Measurement at that point in time is logical, since the Food Summit target was set at roughly the same time as the implementation of the Uruguay Round commitments on agriculture within the World Trade Organization.

[31] Cf. Assumptions of ERS (1997).

[32] Cf. Strauss and Thomas (1995).

and macroeconomic policies. It is assumed that costs are proportionate to the magnitude of the policy change required, and increase with the population of the country, but at a less than proportionate rate.[33]

Both political inertia and opposition to policy changes are certain to surface, requiring pressure to overcome them. To some extent, this pressure may materialize organically as the value of these policy changes becomes better appreciated within the domestic polity. Moreover, to the extent that the sectoral and sub-sectoral initiatives to promote food security are contingent on these policy changes, the incentive to receive the funding for these programs will also provide inducement to change. However, past experience has demonstrated that external forces cannot orchestrate this pressure; rather, domestic policy makers must back policy reform, which is a formidable constraint when considering the large number of countries involved.

Sectoral Level Interventions

Intervention 5: Rural Roads

Logic: Rural road density has been shown to be among the most important contributors to productivity growth in agriculture. This is due, first, to the impact that better roads have in reducing the transport component of input costs and the transaction costs of marketing products. In addition, roads unquestionably improve the flow of information regarding market conditions, new technologies, and potential hazards and risks to rural enterprises. Chan-Kang, *et al* (1999) note that better roads and transportation may improve the timing of agricultural operations, facilitate access to markets, and make productivity gains from specialization possible. Rural roads also improve the competitiveness of non-farm rural activities and increase access to public and private services that support the rural economy. Thus, through these multiple and diverse effects, numerous studies have found that good rural roads are a necessary complement to the success of other activities in rural areas.

The model traces only the most important of these links, e.g. the impact of rural road investment on agricultural labor productivity. This, in turn, is assumed to have a multiplicative effect on aggregate national income. Income growth is then assumed to influence child undernutrition through the three underlying effects measured by Smith and Haddad (Table A.2).

In addition to income effects, improvements in agricultural productivity are also expected to directly increase food availability, as a function of the share of agricultural productivity improvements, which are assumed to accrue to food crops. This direct effect is therefore added to the income effect on food availability and then translated into an impact on undernutrition.

[33] The cost of reforms is modeled by a function which relates the square root of the population to a standard technical assistance package cost. The basic technical package assumes that a country with a population of 100 million people would require 100 million dollars over the thirteen-year period to implement a complete set of policy reforms in favor of political stability, democratization or economic openness. Each function is also weighted by the extent to which the country has already converged with the sought-after reforms. Thus, countries or sub-regions which have the furthest to go hold the potential for the most cost-effective progress in policy reform

Data and Assumptions: Data on rural road density are taken from the World Bank's *World Development Indicators 2000*. Data on agricultural productivity are drawn from Timmer (1997), and, where absent from his estimates, interpolated from data on the agricultural share of GDP and on the rural labor force. Craig, Pardey and Roseboom (1997) have measured the impact of rural roads on agricultural productivity from cross-country data for developing countries. Their data yields a road density elasticity of agricultural labor productivity of 0.09. This elasticity is used in this analysis along with an estimated constant term and an hypothesized second-order quadratic term to take into account diminishing returns as road density increases.[34]

As noted above, the impact on agricultural labor productivity is assumed to translate directly into an increase in agricultural production. This in turn is assumed to affect overall income in the economy. Various studies have evaluated this multiplier for different countries of the world. [35] Spencer (1994) summarizes this evidence, giving multiplier ranges of 1.5 to 2.7 for sub-Saharan Africa and 1.5 to 2.4 for Asia. Based upon his assumptions, the model assumes a multiplier of 2.0 for all countries.

Translating agricultural productivity into changes in food availability is made by a parameter capturing the share of improvements in agricultural productivity that can be assumed to accrue to food crops. Because investments in agricultural research are expected to go to cash crops as well, the assumption made in the analysis is that the impact on food products represents half of the aggregate effect on overall agricultural output.

Rural road construction costs were obtained from the World Bank for construction of rural roads.[36] Costs per kilometer of laterite roads range between $10,000 and $80,000 (1998) depending on terrain, distance to sources of material and other factors. Costs vary a great deal by region and within regions, depending on the weather and decay rates. As a general average, $20,000/km was assumed, representing basic access, an all-weather laterite road built for savanna zones sufficient to accommodate 10 to 40 vehicles per day.

Intervention 6: Agricultural Research

Logic: Agricultural research is crucial to sustaining agricultural productivity growth in the medium to long term. Research and development contributes to new knowledge, which directly affects productivity, such as through new and improved inputs and outputs. Chan-Kang, Pardey, Wood, Roseboom and Cremers (1999) estimate, for example, that improving the knowledge base of African agriculture more than quadruples the production elasticity of fertilizer. As with rural roads, the impact of agricultural research on undernutrition is traced through its impact on

[34] This technique evaluates the intercept b_0 as follows:

$$b_0 = 1/n \sum [\ln (A) - b_1 \ln(R)]$$

where n is the number of observations in the series, A is the agricultural product per capita of rural labor, R is rural road density and b1 is the known partial elasticity relating the two. The second-order term was given a coefficient of -0.012, which yielded a reasonable, but not very large, degree of diminishing returns.

[35] World Bank, direct communication.

[36] World Bank, direct communication.

agricultural productivity, which then has a multiplicative effect on national GDP. Per capita income growth then relates to the three underlying variables causing undernutrition.

In addition to these effects, agricultural research, as with rural roads, is also assumed to increase caloric availability directly through its impact on food production.

Data and Assumptions: The level of current agricultural research has been taken from two main sources. For sub-Saharan Africa, Pardey and others at IFPRI have provided recent expenditure figures. For other regions and countries, these data were not available and therefore estimates were derived from the World Development Indicators 2000 database, which reports expenditure on R&D for many countries. For the 32 developing countries in the data set, the indication is that 0.36% of GDP went to research and development for the period 1987-97. The share of R&D expenditure going to agriculture was then assumed to be proportionate to agriculture's contribution to GDP in each country. For the 32 developing countries in the sample, this led to an estimate of 0.07% of GDP devoted to agricultural research; this parameter used for those developing countries or regions not in the sample. Data assumptions related to agricultural productivity, impacts on national income, and the three underlying causes of undernutrition are identical to those used for the rural roads analysis (Intervention 6).

An elasticity of 0.09 was used to link agricultural research to agricultural productivity growth in all countries. This parameter was borrowed from the analysis by Craig, Pardey, and Roseboom (1997). Although more recent work on Africa (Chan-Kahn, Pardey, Wood, Roseboom and Cremers, 1999) suggests a somewhat weaker effect, the results are not statistically significant. As in the case of rural roads, an intercept parameter was estimated to adjust the elasticity effect to the specific data used in the analysis. The linkage between agricultural productivity and income, and between income and child malnutrition, was the same as for rural roads.

Increases in agricultural output are assumed to have half as great an impact on food availability as on total production in percentage terms. Again, this follows the rural roads example.

In the model, all agricultural research investments are assumed to be sunk in the first three years of the initiative, allowing ten years for them to come to fruition. In addition, it is assumed that research is adaptive in nature and targeted to facilitating technology transfer, so gestation periods are not as long as they would be with more basic research.

There is a growing body of evidence that HIV/AIDS is a severe constraint facing the agriculture sector in Africa, particularly in the ten hardest-hit countries in the southern and central part of the continent (FAO 2000, UN/AIDS). It is safe to assume that interventions to improve agricultural productivity in those regions will be more costly due to the debilitating effects of the pandemic: reduction in area of land under cultivation, declining yields, decline in crop variety and changes in cropping patterns, decline in livestock production (including loss of livestock as savings), and loss of agricultural skills.

Household Level Interventions

Intervention 7: Targeted Food Aid

Logic: The targeted food aid intervention is assumed to be a direct transfer to populations at high risk of undernutrition who are participants in maternal and child health care and small-scale agricultural programs. To evaluate the impact of these transfers, the analysis assumes that the transfer must be sufficient to permanently remove an individual from undernutrition. To do so, the transfer must contain an investment component sufficient to sustain the individuals' income in perpetuity at a level above the threshold of food insecurity. The analysis does not specify what these investments might be, but they do involve the use of food aid for purposes other than simple hand-to-mouth feeding; for example, such investments might include building human capital through education (Intervention 7), access to water or other physical infrastructure which permanently reduces the risks of undernutrition (Intervention 7), or direct investments in productive activities such as agriculture. It is assumed that NGO's will be heavily involved in deciding how these transfers are to be spent, using a variety of techniques such as monetization, food-for-work and the like. While this investment approach to food aid substantially increases up-front costs, it also prompts sufficient transfer per capita to ensure that the impact will be permanent.

Data and Assumptions: To determine the annual income transfer necessary to remove a person from undernutrition, the analysis relies on the poverty gap measure. This measure is the aggregate average daily shortfall in income per person below the poverty line. Moving a person above the poverty line is assumed to concurrently remove the individual from undernutrition, since the line is generally defined to be the income level below which an individual does not have sufficient entitlement to the basic necessities of life.

The analysis assumes that the transfer has the effect of moving one–half of those below the poverty line to a position above the poverty line. The capital requirements to generate the annual cost of doing this are estimated using a capital-output ratio of four. Appendix Table A.3 presents assumptions regarding the poverty gap, and the necessary income transfer needed to reduce undernutrition by one person for each country/sub-region considered in the analysis.

In addition, the income transfer is discounted by a factor (0.75) to reflect the inefficiencies involved in using food aid to transfer income to targeted groups. Two expected improvements in targeted food aid transfers mean that this efficiency parameter is projected to be higher than has been the case in the past (0.6). First, the rapid development of information technologies such as smart cards, telecommunications, and the internet are expected to increase the efficiency of conducting and monitoring income transfers, to improve targeting of the transfers to those suffering undernutrition, and to reduce losses due to fraud which are too often associated with such subsidy schemes. Second, the sale of food aid, generating revenue for transfers, is expected to be handled to an increasing extent by those with experience in multinational grain trade, whether these be international grain companies or experienced NGOs.

Intervention 8: Female Secondary School Education

Logic: The impact of female education on undernutrition operates through a variety of channels. First, more educated women know better how to care for their children with respect to health and diet. Secondly, they are more likely to practice family planning successfully, which allows for better birth spacing and ultimately smaller families. Both of these effects improve the food security prospects for the children who are born. Moreover, schooling, particularly secondary

education, imparts greater status on women, and therefore empowers them within society to procure more and better goods and services for their families. Finally, education has the obvious effect of improving the income-earning potential of the family and thereby increasing its entitlement to food.

Data and Assumptions: Smith and Haddad found that for every 10 percentage points of increased female secondary school enrollment, child undernutrition falls by 1.7 percentage points. This relationship is integrated into the model analysis (see Table A.2.)

The investments in female education are assumed to occur in the first five years, allowing better education to progressively impact households as better-educated girls eventually become mothers. Investment costs are assumed to be recurrent in order to sustain the percentage increase in female secondary school education.

The cost of female secondary school education averages $57/female/year in sub-Saharan Africa and $35/female/year in Asia and the rest of the world. These data are taken from Summers (1994). Note that HIV/AIDS raises the costs of interventions to achieve reductions in undernutrition through female education in most of Africa.

Intervention 9: Access to Safe Water

Logic: Safe water is known to dramatically reduce exposure to a variety of debilitating diseases that directly obstruct the intake and utilization of food by the body. These diseases include dysentery and internal and external parasites, among others. In addition, easier access to safe water reduces the time spent hauling water, increasing the productivity and ultimately the status of women, to whom typically falls the daily task of providing water to the household. Improvement in access to safe water therefore has both direct and indirect effects.

Data and Assumptions: Smith and Haddad found that a ten percentage point improvement in access to safe water reduces child undernutrition by 0.8 percentage points. Investments in safe water are assumed to be feasible at any point in the planning horizon to 2015. Moreover, the impact on undernutrition is assumed to be permanent because investments in safe water infrastructure are assumed to last for more than the 13-year impact period.

Data on current rates of access to safe water are drawn from the World Development Report and UNICEF database. The World Bank has estimated the cost of providing safe water at $15/person in rural areas of developing countries in Latin America and Asia, and at $20/person in rural areas of sub-Saharan Africa (Summers 1994). These costs cover well digging or provision of accessible water point sites, which provide uncontaminated or treated water. Despite their strong effect on food security, the possibilities for investments to provide access to safe water are limited in the model by the fact that, by the year 2015, even without exceptional "food security" investments by the donor community, most countries are projected to have already provided safe water to more than 80% of their households.

The Weighting of Interventions within the Scenarios

The first three scenarios assume that all four policy interventions at the global and national

levels, i.e., reducing war and civil strife, increasing democracy, opening trade and investment policy environment, and reducing barriers to food imports, are achieved through a combination of both international pressure and incentives as well as technical assistance and training at the national level.

In essence, the utility of the AIRD Food Security Model is in showing the relative efficiency in reducing undernutrition of different interventions at the sectoral and household levels. These are:

- construction of rural roads
- agricultural research and extension
- monetized food aid for social sector programs
- female education
- improved access to safe water

Scenario One dedicates more or less the same level of funding to be spent for each person suffering undernutrition in each of the countries and sub-regions and the funds are distributed equally among the interventions. The total cost of achieving the Food Summit target under this scenario is **$124 billion**, with the largest amounts spent in Asia because most undernutrition is concentrated there. Although this scenario may be equitable, it is not very efficient in achieving the target.

In Scenario Two, resources are reallocated in directions leading towards greater cost-effectiveness in achieving the Food Summit target. Investment in rural roads and in safe water are abandoned altogether, and resources are reallocated not only towards other interventions but also marginally towards South Asia to the detriment of most other regions. The result is a substantial reduction in the cost of achieving the target from $124 billion to **$72 billion**. However, a very large part of the reduction in undernutrition comes from investments in agricultural research and female education in South Asia.

Scenario Three is known as the "rational" or "efficiency with equity" scenario. Heavy emphasis is placed especially on war-torn SSA, where substantial gains in nutritional status are possible at only moderate additional cost. Interventions in SSA are also strongly oriented towards agricultural research and female education. The cost of this scenario is **$80 billion**, or about 11% higher than Scenario 2. Further shifts towards Africa could also be undertaken without raising costs too much further.

Scenario Four is the "policy absent" scenario under which there is no progress in reducing war, democratization, or economic policy reform. Under these conditions, investment in roads or agricultural research would be relatively ineffective since conditions would not be ripe to benefit from these investments. Nevertheless, interventions could be attempted at the household level with respect to targeted food aid, female education, and access to safe water, though in the absence of physical security even these would be difficult to implement. This scenario is the most costly at **$126 billion**, with significant risk of cost variability.

Limitations

As is indicated by the discussion above, the analysis of interventions is only able to capture rough orders of magnitude of the impact of each intervention on undernutrition. Weaknesses in the model reflect a lack of empirical measurements of relationships, insufficient data, and structural simplifications in the model. Some of these elements are identified below in order to provide guidance for research to improve the analysis.
Insufficient or weak empirical evidence/data:

- The numbers of current and projected undernutrition above 4 years of age as determined by anthropometric measurements.
- The effects of specific interventions on people above 4 years of age suffering undernutrition.
- Evidence of other pathways, beyond the three underlying variables, through which interventions affect undernutrition. This exercise provided an indication of the relative cost-effectiveness among several of the main sectoral and household types of interventions available. There is a risk that strong explanatory variables are being overlooked, despite the interdisciplinary approach taken in the analysis.
- Evidence of interactions among different interventions, which either increase or reduce their effectiveness in achieving the objective.
- More specificity for countries and regions with respect to parameters of impact for each intervention and with respect to intervention costs.

Structural deficiencies in the model include:

- Lack of detail regarding the differences between urban and rural undernutrition
- Lack of inter-temporal analysis of flow of investment and impact for each intervention
- Need for inclusion of interactions between different interventions
- Need to incorporate better declining marginal impacts, constraints on absorptive capacity, preconditions, and other constraints to effectiveness for each intervention
- Need to incorporate costs of capacity-building for sustainable interventions. For example, the additional cost of providing extension services in support of the basic adaptive research must be considered in order to reflect total costs.

Despite these limitations, the model does provide a rough assessment of the relative impact of alternative interventions to address chronic undernutrition. Absolute numbers are only indicative of orders of magnitude. This assessment can provide guidance for developing a general strategy to address undernutrition. The model also provides a framework for further research and identifies important lacunae in current understanding of the cost effectiveness of alternative interventions to reduce undernutrition.

Table A.3: NATIONAL LEVEL FOOD SECURITY STRATEGY INTERVENTIONS

			East & SE Asia			South Asia			Sub-Saharan Africa							
			China	Indonesia	Other E, SE Asia	Pakistan	Bangladesh	India	Other S. Asia	Nigeria	Ethiopia	Other War torn SSA	Other LDC SSA	Other Developing S.S.	Latin America	Rest of World
Political Reforms																
a.	Increase Political stability	Target:	0.00	Establish peace (drop indicator to 0)												
	Current Indicator	War torn	0.00	0.00	0.25	0.00	0.00	0.00	0.46	0.00	1.00	1.00	0.00	0.00	0.11	0.46
	Impact on All Undernutrition	% change in prevalence	0.00	0.00	-1.98	0.00	0.00	0.00	-3.66	0.00	-8.00	-8.00	0.00	0.00	-0.90	-3.66
		Millions	0.00	0.00	-1.30	0.00	0.00	0.00	-0.60	0.00	-1.98	-4.80	0.00	0.00	-0.22	-2.07
	Impact on Children in Undernutrition	% change in prevalence	0.00	0.00	-1.98	0.00	0.00	0.00	-3.66	0.00	-8.00	-8.00	0.00	0.00	-0.90	-3.66
		Millions	0.00	0.00	-0.42	0.00	0.00	0.00	-0.26	0.00	-1.14	-3.00	0.00	0.00	-0.10	-1.03
b.	Promote Democracy	Target:	0.30	reduction in difference between actual and optimal level												
	Indicator 2000	Democracy index	0.80	1.70	4.59	3.10	2.50	4.50	2.48	1.40	3.00	0.88	1.03	2.09	4.30	2.13
	Change in democratization index	INDEX PONTS	1.86	1.59	0.72	1.17	1.35	0.75	1.36	1.68	1.20	1.83	1.79	1.47	0.81	1.46
	Impact on access to safe water	% change with access to safe water	0.06	0.06	0.03	0.04	0.05	0.03	0.05	0.06	0.04	0.06	0.06	0.05	0.03	0.05
	Impact on All Undernutrition	% change in prevalence	-0.47	-0.40	-0.18	-0.29	-0.34	-0.19	-0.34	-0.42	-0.30	-0.46	-0.45	-0.37	-0.20	-0.37
		Millions	-0.44	-0.18	-0.12	-0.15	-0.17	-0.65	-0.06	-0.16	-0.07	-0.28	-0.14	-0.04	-0.05	-0.21
	Impact on Children in Undernutrition	% change in prevalence	-0.47	-0.40	-0.18	-0.29	-0.34	-0.19	-0.34	-0.42	-0.30	-0.46	-0.45	-0.37	-0.20	-0.37
		Millions	-0.14	-0.07	-0.04	-0.08	-0.08	-0.26	-0.02	-0.09	-0.04	-0.17	-0.09	-0.02	-0.02	-0.10
Economic Reforms																
c.	Economic openness	Target:	1.00	Sachs/Warner index target to 1 by 2005												
	Indicators	S&W Openness	0.00	1.00	0.55	0.00	0.00	0.00	0.33	0.00	0.00	0.12	0.12	0.24	0.75	0.41
	Indirect effect on income growth via trade	addition to rate of growth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Direct effect on incomes via growth	addition to rate of growth	0.02	0.00	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01
	Compounded impact on percapita income	% change 2002-2015	0.15	0.00	0.06	0.15	0.15	0.15	0.10	0.15	0.15	0.13	0.13	0.11	0.04	0.09
	Impact on All Undernutrition	% change in prevalence	-2.64	0.00	-3.69	-2.53	-2.67	-2.24	-2.33	-1.74	-0.56	-1.19	-1.04	-2.88	-1.40	-5.06
		Millions	-2.46	0.00	-2.43	-1.29	-1.37	-7.68	-0.38	-0.65	-0.14	-0.71	-0.33	-0.33	-0.34	-2.86
	Impact on Children in Undernutrition	% change in prevalence	-2.64	0.00	-3.69	-2.53	-2.67	-2.24	-2.33	-1.74	-0.56	-1.19	-1.04	-2.88	-1.40	-5.06
		Millions	-0.81	0.00	-0.79	-0.67	-0.62	-3.14	-0.16	-0.37	-0.08	-0.45	-0.21	-0.19	-0.16	-1.43
d.	Reduce food import tariffs	Target:	0.10	Maximum tariff												
	Indicator	Current food staple NPC	1.07	1.67	1.94	1.01	1.49	1.08	1.90	3.20	1.59	1.80	2.11	1.25	1.33	1.82
	Domestic price effect of meeting target	% change in dom. price	0.00	-0.34	-0.43	0.00	-0.26	0.00	-0.42	-0.66	-0.31	-0.39	-0.48	-0.12	-0.17	-0.40
	Impact on food availability	% change in DES	0.00	0.07	0.09	0.00	0.05	0.00	0.08	0.13	0.06	0.08	0.10	0.02	0.03	0.08
	Impact on All Undernutrition	% change in prevalence	0.00	-11.91	-14.16	0.00	-6.83	0.00	-11.93	-17.52	-6.52	-9.69	-13.84	-3.70	-5.66	-14.54
		Millions	0.00	-5.28	-9.34	0.00	-3.52	0.00	-1.95	-6.55	-1.61	-5.81	-4.37	-0.42	-1.37	-8.22
	Impact on Children in Undernutrition	% change in prevalence	0.00	-11.91	-14.16	0.00	-6.83	0.00	-11.93	-17.52	-6.52	-9.69	-13.84	-3.70	-5.66	-14.54
		Millions	0.00	-2.08	-3.02	0.00	-1.59	0.00	-0.84	-3.69	-0.93	-3.64	-2.72	-0.24	-0.65	-4.11
	Note:	Regional indicators are population weighted averages for countries in each region for which data exists														

Table A.4: SECTORAL FOOD SECURITY STRATEGY INTERVENTIONS

			East & SE Asia				South Asia			Sub-Saharan Africa						
			China	Indonesia	Other E,SE Asia	Pakistan	Banglades h	India	Other South Asia	Nigeria	Ethiopia	Other War torn SSA	Other LDC SSA	Developin g S.S. Africa	Latin America	Rest of World
II.	Sectoral Indicators															
	Agricultural GDP/Capita	$PPP, 1985	444.00	677.00	677.00	642.00	789.00	623.00	800.00	800.00	255.21	623.50	544.60	1786.09	75.86	74.67
	Rural Population	millions	836.57	126.98	200.41	84.90	97.85	680.29	32.59	67.54	48.85	116.07	81.45	81.92	117.04	146.68
	Agricultural Share of GDP	%	18.39	19.54	20.28	26.42	22.19	29.32	20.28	31.68	49.77	20.28	50.00	20.28	13.15	15.27
a.	Investment in rural infrastructure	Target:	0.50 per capita undernourished													
	Rural road density	(km/km2)	0.21	0.79	1.03	0.66	0.13	0.90	0.17	0.16	0.07	0.31	0.21	0.61	0.41	0.30
	Current rural road resource on agricultural la	Rural roads (km)	191929	134946	46841	136869	12738	1501073	12512	47104	6835	9628	4353	11670	23014	18025
	Change in rural road km	% change	0.00	0.00	0.00	0.00	1.01	0.00	0.33	0.30	1.36	2.34	2.72	0.00	0.00	0.00
	Impact on labor productivity	% change	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.08	-0.01	0.00	0.00	0.00	0.00
	Impact on Income	% change	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
	Direct Impact on Food Availability	% change	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.06	-0.01	0.00	0.00	0.00	0.00
	Impact on All Undernutrition	% change in prevalence	0.00	0.00	0.00	0.00	-1.45	0.00	-0.63	-0.62	-6.40	0.85	-0.19	0.00	0.00	0.00
		Millions	0.00	0.00	0.00	0.00	-0.75	0.00	-0.10	-0.23	-1.58	0.51	-0.06	0.00	0.00	0.00
	Impact on Children in Undernutrition	% change in prevalence	0.00	0.00	0.00	0.00	-1.45	0.00	-0.63	-0.62	-6.40	0.85	-0.19	0.00	0.00	0.00
		Millions	0.00	0.00	0.00	0.00	-0.34	0.00	-0.04	-0.13	-0.91	0.32	-0.04	0.00	0.00	0.00
b.	Investment in agricultural research	Target	3.00 per capita undernourished													
	Current investment in research for agricultur	$ total million	2174.78	55.57	483.65	452.09	12.04	2514.54	99.34	86.90	40.50	141.00	112.90	254.59	494.38	1198.72
	Investment in ag. research/capita rural pop	$ per capita rural pop.	2.60	0.44	2.41	5.33	0.12	3.70	3.05	1.29	0.83	1.21	1.39	3.11	4.22	8.17
	Change in agric research	% change	0.01	0.16	0.27	0.11	8.55	0.14	0.33	1.29	2.44	1.70	1.12	0.09	0.00	0.00
	Cumulative increase in labor productivity	% change	0.00	0.05	0.09	0.04	0.90	0.05	0.10	0.31	0.47	0.37	0.28	0.03	0.00	0.00
	Impact on income	% change	0.00	0.02	0.04	0.02	0.40	0.03	0.04	0.20	0.47	0.15	0.28	0.01	0.00	0.00
	Direct Impact on Food Availability	% change	0.00	0.04	0.07	0.03	0.68	0.03	0.08	0.23	0.35	0.28	0.21	0.02	0.00	0.00
	Impact on All Undernutrition	% change in prevalence	-0.44	-7.66	-12.97	-4.84	-74.62	-5.75	-12.05	-32.03	-36.01	-33.69	-30.99	-3.98	0.00	0.00
		Millions	-0.41	-3.40	-8.56	-2.46	-38.41	-19.73	-1.97	-11.98	-8.91	-20.21	-9.78	-0.46	0.00	0.00
	Impact on Children in Undernutrition	% change in prevalence	-0.44	-7.66	-12.97	-4.84	-74.62	-5.75	-12.05	-32.03	-36.01	-33.69	-30.99	-3.98	0.00	0.00
		Millions	-0.13	-1.34	-2.76	-1.28	-17.32	-8.07	-0.85	-6.75	-5.14	-12.65	-6.10	-0.26	0.00	0.00

Table 5: HOUSEHOLD AND INTRA HOUSEHOLD FOOD SECURITY STRATEGY INTERVENTIONS

			East & SE Asia			South Asia			Sub-Saharan Africa							
			China	Indonesia	Other E,SE Asia	Pakistan	Bangladesh	India	Other South Asia	Nigeria	Ethiopia	Other War torn SSA	Other LDC SSA	Other Developing S.S. Africa	Latin America	Rest of World
a.	Targeted Food AID															
	Poverty Gap	Daily cents per cap. deficien	9.20	2.00	2.60	2.60	7.00	15.60	11.55	11.70	8.00	13.00	23.61	13.43	10.04	0.60
	Income transfer to remove one person from p	$/year/person	223.87	48.67	63.27	63.27	170.33	379.60	281.05	284.70	194.67	316.33	574.61	326.88	244.38	14.60
	Impact on All Undernutrition	% change in prevalence	0.00	-18.49	-94.84	-47.42	-26.42	-11.85	-16.01	-15.81	-23.12	-14.23	-7.83	0.00	0.00	0.00
		Millions	0.00	-8.20	-62.58	-24.16	-13.60	-40.66	-2.62	-5.91	-5.72	-8.53	-2.47	0.00	0.00	0.00
	Impact on Children in Undernutrition	% change in prevalence	0.00	-46.83	-293.51	-91.06	-58.60	-28.99	-37.30	-28.06	-40.07	-22.72	-12.56	0.00	0.00	0.00
		Millions	0.00	-8.20	-62.58	-24.16	-13.60	-40.66	-2.62	-5.91	-5.72	-8.53	-2.47	0.00	0.00	0.00
b.	Empower Women	Target investment	3.00	per capita undernourished												
	# Females 15-19	Millions	46.10	10.30	14.47	6.39	6.13	43.79	1.89	6.21	2.84	8.49	6.05	7.41	20.91	15.43
	Projected % Female Secondary enrollment, 2	%	0.71	0.64	0.70	0.84	0.84	0.11	0.91	0.63	0.54	0.54	0.54	0.69	0.61	0.63
	Annual additional females enrolled	millions	0.00	0.00	4.36	1.01	0.98	38.92	0.17	1.60	1.29	2.57	2.71	0.00	0.00	0.00
	Impact on All Undernutrition	% change in prevalence	0.00	0.00	-7.00	-3.67	-3.71	-20.62	-2.09	-5.99	-10.57	-7.03	-10.37	0.00	0.00	0.00
		Millions	0.00	0.00	-4.62	-1.87	-1.91	-70.71	-0.34	-2.24	-2.61	-4.21	-3.27	0.00	0.00	0.00
	Impact on Children in Undernutrition	% change in prevalence	0.00	0.00	-7.00	-3.67	-3.71	-20.62	-2.09	-5.99	-10.57	-7.03	-10.37	0.00	0.00	0.00
		Millions	0.00	0.00	-1.49	-0.97	-0.86	-28.92	-0.15	-1.26	-1.51	-2.64	-2.04	0.00	0.00	0.00
c.	Increase access to safe water	Target expenditure	0.10	per capita undernourished												
	Projected Access to safe water 2015	% with Safe water	0.86	0.69	0.71	0.66	0.85	0.68	0.52	0.58	0.47	0.55	0.66	0.74	0.75	0.78
	# of additional people w/access	Millions	0.00	0.00	0.88	0.00	0.69	4.57	0.22	0.37	0.25	0.60	0.32	0.00	0.00	0.00
	Impact on All Undernutrition	% change in prevalence	0.00	0.00	-0.01	0.00	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	-0.01	0.00	0.00	0.00
		Millions	0.00	0.00	-0.01	0.00	-0.02	-0.09	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
	Impact on Children in Undernutrition	% change in prevalence	0.00	0.00	-0.01	0.00	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	-0.01	0.00	0.00	0.00
		Millions	0.00	0.00	0.00	0.00	-0.01	-0.04	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00

Table A.6: Base Parameters for Food Security Model

		China	Indonesia	Rest East,SE Asia	Pakistan	Banglades h	India	Rest South Asia	Nigeria	Ethiopia	War torn Africa	Peaceful LDC Africa	Rest SS Africa	Latin America
FOOD SECURITY PARAMETERS														
Dietary Energy Supply	Kcal/capita	2710.0	2700.0	2549.1	2340.0	1990.0	2330.0	2185.0	2100.0	1620.0	1906.2	2243.1	2351.7	2500.0
% undernourished (IFPRI or AIRD estimate, based on FAO measure)	% 1990/92	16.0	12.0	17.4	17.0	34.0	21.0	27.5	38.0	65.0	51.4	33.2	31.0	22.0
Number of undernoursined (FAO measure)	Million, 1995	192.0	23.2	62.5	22.1	40.7	195.2	10.9	42.3	36.7	73.4	40.5	36.5	66.2
% children undernourished (WHO measure)	% 1990/95	21.0	38.0	27.8	40.4	66.5	53.0	46.3	35.4	39.8	31.4	24.7	18.0	11.5
Number undernourished children (WHO measure)	Million, 0-5 yrs, '95	22.5	8.0	9.1	8.6	10.2	59.3	2.3	6.9	4.5	9.1	5.1	4.5	6.2
UNDERLYING CHARACTERISTICS														
Population , 1995	Millions	1200.2	193.3	357.8	129.9	119.8	929.4	39.6	111.3	56.4	158.1	112.7	138.1	461.3
Income per capita	$, 1985	1493.0	2102.0	4867.1	1432.0	1510.0	1264.0	2013.5	978.0	312.0	762.2	665.8	2183.5	3281.5
Poverty gap ($/capita deficit of poor)	$, 1985	9.2	2.0	2.6	2.6	na	15.6	11.6	11.7	8.0	13.0	23.6	13.4	10.0
Female Illiteracy rate	%	27.3	22.0	18.8	75.6	73.9	62.3	52.1	52.7	74.7	63.6	63.1	39.7	16.3
Female primary school enrollment rate	%	116.0	112.0	92.1	48.5	105.0	91.0	98.5	82.0	19.0	55.6	61.1	99.8	97.4
Access to safe water	%	82.8	63.0	63.8	60.0	83.0	63.0	48.0	43.0	27.0	39.2	52.3	64.8	75.9
Access to sanitation	%		55.4	68.6	30.0	30.0	29.0	26.0	63.3	10.0	27.7	35.5	56.3	67.3
OTHER DATA														
Vulnerable groups														
Smallholder farmers			281349.0		13486.0	60167.0	75626.0			30606.0				
Landless			179584.0		23799.0	19010.0	19227.0			6278.0				
Nomadic pastoralist			0.0		1904.0	0.0	0.0		na					
Small fishermen			7782.0		873.0	6112.0	16791.0		na				2.6	
Refugees			247.0		3955.0	0.0	2.0			701.0			0.1	
Households headed by women			89790.0		6902.0	15280.0	25636.0			21581.0				
Population , 2015	millions	1417.7	250.4	465.0	222.6	161.5	1211.7	54.6	153.3	90.9	268.0	185.4	188.0	607.4
Income/cap of poorest	$, 1985	89.9	192.5	384.3	117.1	141.2	112.8	135.8	38.9	20.0	48.8	32.4	125.9	148.6
Share of income to poorest	% of average	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0
Openness		0.0	1.0	0.5	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.2	0.3	0.7
Ratio life expectancy women to men		1.0	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
Rural road density to ag. Land	(km/km2)	0.2	0.8	4.8	0.7	0.1	0.9	0.2	0.2	0.1	0.3	0.3	0.5	0.9

Table A.7
Analysis of Variables Affecting Percentage of Children Nourished

	I		II		III		IV		V		VI	
	Coeff	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**
C	-22.3471	7.4944	-50.1617	21.7052	-10.2309	79.2236	-13.0541	77.6590	3.2068	74.6698	-53.2342	19.8015
ESEA	-15.3930 ***	4.1479	-16.7349 ***	4.2067	-16.8116 ***	4.2628	-17.5729 ***	3.6627	-17.2041 ***	3.6151	-17.5043 ***	3.6167
SA	-20.3428 ***	3.8967	-22.9880 ***	4.3046	-23.3808 ***	4.4232	-24.1148 ***	3.8813	-25.0075 ***	3.7049	-23.7281 ***	3.7679
LDES					-6.0615	11.5540	-6.0942	11.3797	-10.0906	10.2257		
LGDPCAP			4.2246	3.0998	5.1086	3.5628	5.8090 *	2.9578	7.3829 ***	2.2373	4.9281 *	2.4288
URB	0.1128	0.0757	0.0351	0.0939	0.0348	0.0951						
WAR	-9.2498 **	3.9302	-7.7788 *	4.0227	-8.2403 *	4.1678	-8.5082 **	4.0411	-8.2392 **	4.0056	-8.0472 **	3.9011
ILLW	-0.0977	0.0597	-0.0684	0.0627	-0.0529	0.0701	-0.0561	0.0685			-0.0718	0.0611
SAN	0.1257 **	0.0596	0.0988	0.0620	0.1041	0.0636	0.1001	0.0618	0.1161 *	0.0583	0.0948	0.0602
POVGAP	-0.2863 **	0.1147	-0.2272 *	0.1211	-0.2387 *	0.1246	-0.2419 *	0.1224	-0.2215 *	0.1192	-0.2303 *	0.1191
Adj. R-sq	0.77		0.78		0.78		0.78		0.78		0.79	
N	38		38		38		38		38		38	

Note
Variables: C = constant
ESEA = East and South East Asia
SA = South Asia
LDES = log of Dietary Energy Supply (Kcal per capita , annual, 1992, FAO)
LGDPCAP =Log of Income per capita, ($ PPP) Penn tables.
URB = % Urbanization of population
WAR = whether there has been protracted conditions of war since 1985
ILLW = female illiteracy rate
SAN = Percent of population with access to sanitation
POVGAP = Poverty gap (Cents/day /person)

Table A.8:

Country Sample and Categorization by Region

Country	Regions	South east Asia	South Asia	Wartorn Africa	LDC Africa	Developing Africa	Latin America	Rest of World
		0	0	0	0	0		
Afghanistan	4	0	0	0	0	0	0	0
Algeria	6	0	0	0	0	0	0	0
Angola	1	0	0	1	0	0	0	0
Argentina	5	0	0	0	0	0	1	0
Bangladesh	2	0	0	0	0	0	0	1
Benin	1	0	0	0	1	0	0	0
Bolivia	5	0	0	0	0	0	1	0
Botswana	1	0	0	0	0	1	0	0
Brazil	5	0	0	0	0	0	1	0
Burkina Faso	1	0	0	0	1	0	0	0
Burundi	1	0	0	1	0	0	0	0
Cambodia	3	1	0	0	0	0	0	0
Cameroon	1	0	0	0	0	1	0	0
Central African Republic	1	0	0	1	0	0	0	0
Chad	1	0	0	1	0	0	0	0
Chile	5	0	0	0	0	0	1	0
China	3	0	0	0	0	0	0	1
Colombia	5	0	0	0	0	0	1	0
Congo Rep .	1	0	0	1	0	0	0	0
Costa Rica	5	0	0	0	0	0	1	0
Cote d'Ivoire	1	0	0	0	0	1	0	0
Cuba	5	0	0	0	0	0	1	0
Dominican Republic	5	0	0	0	0	0	1	0
Egypt, Arab Rep.	6	0	0	0	0	0	0	0
El Salvador	5	0	0	0	0	0	1	0
Ethiopia	0.5	0	0	0	0	0	0	0
Gabon	1	0	0	0	0	1	0	0
Gambia, The	1	0	0	0	1	0	0	0
Ghana	1	0	0	0	0	1	0	0
Guatemala	5	0	0	0	0	0	1	0
Guinea	1	0	0	0	1	0	0	0
Guyana	5	0	0	0	0	0	1	0
Haiti	5	0	0	0	0	0	1	0
Honduras	5	0	0	0	0	0	1	0
Hong Kong	3	1	0	0	0	0	0	0
India	2	0	0	0	0	0	0	1
Indonesia	3	0	0	0	0	0	0	1
Iran, Islamic Rep.	6	0	0	0	0	0	0	0

Iraq	0	0	0	0	0	0	0	0
Jamaica	5	0	0	0	0	0	1	0
Jordan	6	0	0	0	0	0	0	0
Kenya	1	0	0	0	0	1	0	0
Korea, Dem. Rep.	3	1	0	0	0	0	0	0
Korea, Rep.	3	1	0	0	0	0	0	0
Kuwait	6	0	0	0	0	0	0	0
Lao PDR	3	1	0	0	0	0	0	0
Lebanon	6	0	0	0	0	0	0	0
Lesotho	1	0	0	0	1	0	0	0
Liberia	1	0	0	1	0	0	0	0
Libya	6	0	0	0	0	0	0	0
Madagascar	1	0	0	0	1	0	0	0
Malawi	1	0	0	0	1	0	0	0
Malaysia	3	1	0	0	0	0	0	0
Mali	1	0	0	0	1	0	0	0
Mauritania	1	0	0	0	1	0	0	0
Mauritius	1	0	0	0	0	1	0	0
Mexico	5	0	0	0	0	0	1	0
Mongolia	3	1	0	0	0	0	0	0
Morocco	6	0	0	0	0	0	0	0
Mozambique	1	0	0	1	0	0	0	0
Myanmar	3	1	0	0	0	0	0	0
Namibia	1	0	0	0	0	1	0	0
Nepal	2	0	1	0	0	0	0	0
Nicaragua	5	0	0	0	0	0	1	0
Niger	1	0	0	0	1	0	0	0
Nigeria	0.5	0	0	0	0	**0**	0	0
Pakistan	2	0	**0**	0	0	0	0	1
Panama	5	0	0	0	0	0	1	0
Paraguay	5	0	0	0	0	0	1	0
Peru	5	0	0	0	0	0	1	0
Philippines	3	1	0	0	0	0	0	0
Rwanda	1	0	0	1	0	0	0	0
Saudi Arabia	6	0	0	0	0	0	0	0
Senegal	1	0	0	0	0	1	0	0
Sierra Leone	1	0	0	1	0	0	0	0
Somalia	1	0	0	1	0	0	0	0
South Africa	1	0	0	0	0	1	0	0
Sri Lanka	2	0	1	0	0	0	0	0
Sudan	1	0	0	1	0	0	0	0
Suriname	5	0	0	0	0	0	1	0
Swaziland	1	0	0	0	0	1	0	0
Tanzania	1	0	0	0	1	0	0	0
Thailand	3	1	0	0	0	0	0	0
Togo	1	0	0	0	1	0	0	0

Trinidad and Tobago	5	0	0	0	0	0	1	0
Tunisia	6	0	0	0	0	0	0	0
Turkey	6	0	0	0	0	0	0	0
Uganda	1	0	0	1	0	0	0	0
United Arab Emirates	6	0	0	0	0	0	0	0
Uruguay	5	0	0	0	0	0	1	0
Venezuela	5	0	0	0	0	0	1	0
Vietnam	3	1	0	0	0	0	0	0
Yemen, Rep.	6	0	0	0	0	0	0	0
Zaire	1	0	0	1	0	0	0	0
Zambia	1	0	0	0	1	0	0	0
Zimbabwe	1	0	0	0	0	1	0	0

Model Organization

The Excel model contains five principal sheets.

Parameters contains the parameters which determine the relationships between various independent variables and undernutrition. This sheet presents a variety of parameters but only those boxed in blue are used by the model.

Regional presents summary data by country and region that the analysis focuses on . These include current and projected levels of undernutrition as well as summary characteristics of underlying variables that influence levels of undernutrition.

Main data Contains data by country used by the model. Other worksheets (Impact and Regions) use database commands to extract data from this base for the analysis.

Impact is the core of the model and presents the analysis of the nine interventions identified above.

Results contains a table at the top linked to the Impact sheet which summarizes the results of a particular scenario. The values of the results are copied from this table to other space to save the results of a particular scenario before changing the scenario.

ANNEX B
Estimation of Impact of Nutrition on Health Expenditures

Objective

The objective of this study is to determine what influence, if any, undernutrition has on public health and the cost of health care.

Data

Data used in this study include: total health expenditures per capita, public health expenditures per capita, GDP per capita, the prevalence of undernutrition, the depth of undernutrition, infant mortality, and a basic health indicator. Health expenditures (total and public) and GDP are measured in international dollars. Infant mortality and the prevalence of undernutrition are measured in percents of the total population. The depth of undernutrition is measured in kilocalories per day. The basic health indicator is measured on a scale of 0 to 1, 1 being optimal.

The data are derived from three sources. Total health expenditures per capita, GDP per capita, and one measure of the prevalence of undernutrition come from the 2000 World Development Indicators (WDI) database. This measure is one of infant and child (years 0 – 4) undernutrition, based on anthropometric measurement of stunting and wasting from WHO. Health expenditures per capita and GDP per capita are averaged over the years 1996 to 1998. Because of a relatively small number of observations, the prevalence of undernutrition is averaged over a longer period of time, 1993 to 1998. Another measure of the prevalence of undernutrition, along with the depth of undernutrition, comes from The Committee on Food Security (FAO) (2000). These data, based on FAO's measurement of per capita dietary energy supplies (DES), were averaged over 1996 to 1998. Public health expenditures per capita, infant mortality, and the basic health indicator (DALE) come from the World Health Organization (1999).[37] Infant mortality data are from 1998, whereas public health care expenditure and basic health indicator data are from 1997.

Regression Results

Ordinary least-squares regression analysis was used to test for relationships in the data. Table I includes a total of eight specifications for two dependent variables; infant mortality and public health care expenditures. The data set includes 189 countries. However, because most variables do not have data for all countries, the number of observations in Table 1 ranges from 75 to 152.

First, the effect of undernutrition on health care costs, holding GDP constant, is examined. Results show a fairly strong association between undernutrition and public health care expenditures. The same is not true of total health care expenditures (not shown).

Next, the effect of undernutrition on a direct indicator of health was examined. Both infant mortality and the basic health indicator were used to measure the level of health. Results indicated that infant mortality is especially sensitive to the prevalence of undernutrition.

[37] The basic health indicator is an index of the performance on health level (DALE).

The FAO level of undernutrition, with GDP held constant, is a statistically significant indicator of infant mortality. When the depth of undernutrition is introduced, however, this proves to be a far superior predictor. Results suggest that the WHO measure based on anthropometric data is statistically even more significant than the FAO measure. Unlike the FAO indicator, moreover, the WHO measure continues to be a strong indicator of infant mortality when severity of undernutrition is introduced.

Implications

The statistical results suggest that undernutrition does have a negative impact on public health care expenditures. This is shown both directly and as a two-step process. Undernutrition is strongly correlated with infant mortality, which, in turn, is strongly correlated with public health care expenditures. Although these results vary somewhat in magnitude, they suggest that a one percent decline in the prevalence of undernutrition leads to a reduction in public health expenditures on the order of $1 per person for the entire population.

Table B.1 Infant Mortality and Public Health Expenditure Regressions

Variable	Public Health Expenditures Per Capita			Infant Mortality Rate				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Per Capita GDP	0.042 (14.27)***	0.045 (16.20)***	0.060 (22.62)***	-6.75E-04 (5.76)***	-2.37E-04 (3.79)***	-3.41E-04 (4.04)***	-5.84E-04 (4.94)***	-3.22E-04 (3.13)***
Prevalence of Malnourishment (FAO)	0.968 (1.97)**	…	…	0.076 (3.95)***	…	…	-0.015 (0.39)	…
Prevalence of Malnourishment (WDI)	…	0.617 (0.68)	…	…	0.110 (5.42)***	…	…	0.066 (3.02)***
Infant Mortality	…	…	13.223 (2.37)**	…	…	…	…	…
Average Food Deficit Per Malnourished	…	…	…	…	…	0.026 (6.56)***	0.026 (2.72)***	0.015 (3.02)***
Constant	-68.576 (3.51)***	-71.699 (2.53)***	-190.716 (4.38)***	6.452 (8.38)***	4.232 (6.62)***	0.633 (0.52)	1.801 (0.97)	1.850 (1.40)
Adjusted R^2	.746	.810	.845	.567	.525	.618	.595	.603
Included Observations	97	83	152	97	81	111	97	75

Note: The top statistics are coefficients. Below in parenthesis are absolute values of t-statistics.
* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.